Erosion Prevention and Sediment Control Manual

City of Gresham, Oregon

Watershed Division
Department of Environmental Services
1333 NW Eastman Parkway
Gresham, Oregon 97030-3813

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Chapter 1 Introduction

1.0 Introduction

The City of Gresham is committed to enhancing, protecting and maintaining the livability of the community and the quality of the water. Within the jurisdictional boundaries of the City of Gresham, sensitive areas include, but are not limited to, the Columbia Slough and Johnson, Fairview, and Kelly Creeks and their tributaries.

EPSC measures are required on all construction sites that disturb soil within the City of Gresham.

Based on the fact that the stream's within the city limits are listed as degraded on the state's water quality limited streams 303 (d) list, one of the City's primary goals is implementation of an erosion prevention and sediment control program that prevents sediment and other stormwater pollutants from entering streams.

This *Erosion Prevention and Sediment Control Manual (Manual)* has been prepared to support development of stormwater best management practices (BMPs) for construction sites required to comply with the NPDES 1200-C General Permit, current state turbidity rule, and City of Gresham requirements for small and large projects. Keep in mind that City requirements may be more stringent than DEQ requirements.

1.1 Objective of the Manual

This *Manual* provides users with a standardized set of procedures and tools: best management practices (BMPs) for implementation on construction projects throughout the City of Gresham. When appropriately designed and implemented, the BMPs will reduce water quality impacts by land-disturbing activities.

The City of Gresham requires an Erosion Prevention and Sediment Control Plan for most construction activities and an NPDES 1200-C permit for site disturbance of one acre or more.

The authority for this Manual is derived from the *Gresham Community Development Code (GDC), Gresham Revised Code (GRC), and the Gresham Public Works Standards (GPWS)*, which directs users on compliance with the Oregon Department of Environmental Quality's National Pollutant Discharge Elimination System (NPDES) stormwater permitting program, specifically 1200-C.

This Manual provides detailed and comprehensive direction for the engineers and designers in the construction industry, contractors, and other potential permittees and applicants to facilitate effective implementation and maintenance of erosion and sediment control measures. Permit applicants will find the necessary information for complying with City of Gresham procedures for Erosion Prevention and Sediment Control Plans and builder responsibilities.

1.2 How to Use this Manual

At the time of writing, this *Manual* provides the most up-to-date erosion prevention, runoff, and sediment control best management practices (BMPs) that are considered effective by the State and the City. The *Manual* assists with the identification and implementation of BMPs appropriate for site specific conditions and is for use by design and construction professionals involved with the planning, design, construction, and oversight of projects..

Approval of an Erosion Prevention and Sediment Control Plan by the City does not relieve the applicant of responsibility to ensure that control measures are constructed and maintained to contain sediment on the construction site.

Personnel that do not have extensive expertise in designing and implementing erosion and sediment control measures will benefit from review of the entire *Manual*. Personnel that have previous experience with the planning, design and implementation of construction stormwater BMPs may benefit primarily from the information provided in individual BMP details.

Chapters 2 and 3 are designed to aid users of this *Manual* through the initial BMP selection process. The process is simplified for single-family/duplex residential construction (Chapter 2). More options are available for addressing larger and more complex development projects (Chapter 3). Users are allowed to choose between some practices, but are required to implement others. Monitoring, maintenance, and enforcement of BMPs are covered in Chapter 4. Details of each BMP are coded by category and found in Chapter 5. The reader will find BMPs arranged and described by their primary role in pollution discharge elimination processes; that is, erosion prevention, sediment control, and runoff control. Usually, users select a combination of BMPs from multiple categories to provide layers of insurance for their site. Throughout the selection process, users should take into account the benefits and limitations of each BMP considered. BMP success is contingent not only on appropriate design and implementation, but on proper maintenance and the coordination and communication between the designers, engineers, and the field construction teams. Finally, Chapter 6 describes non-stormwater pollution controls to address potential pollution pathways at construction sites.

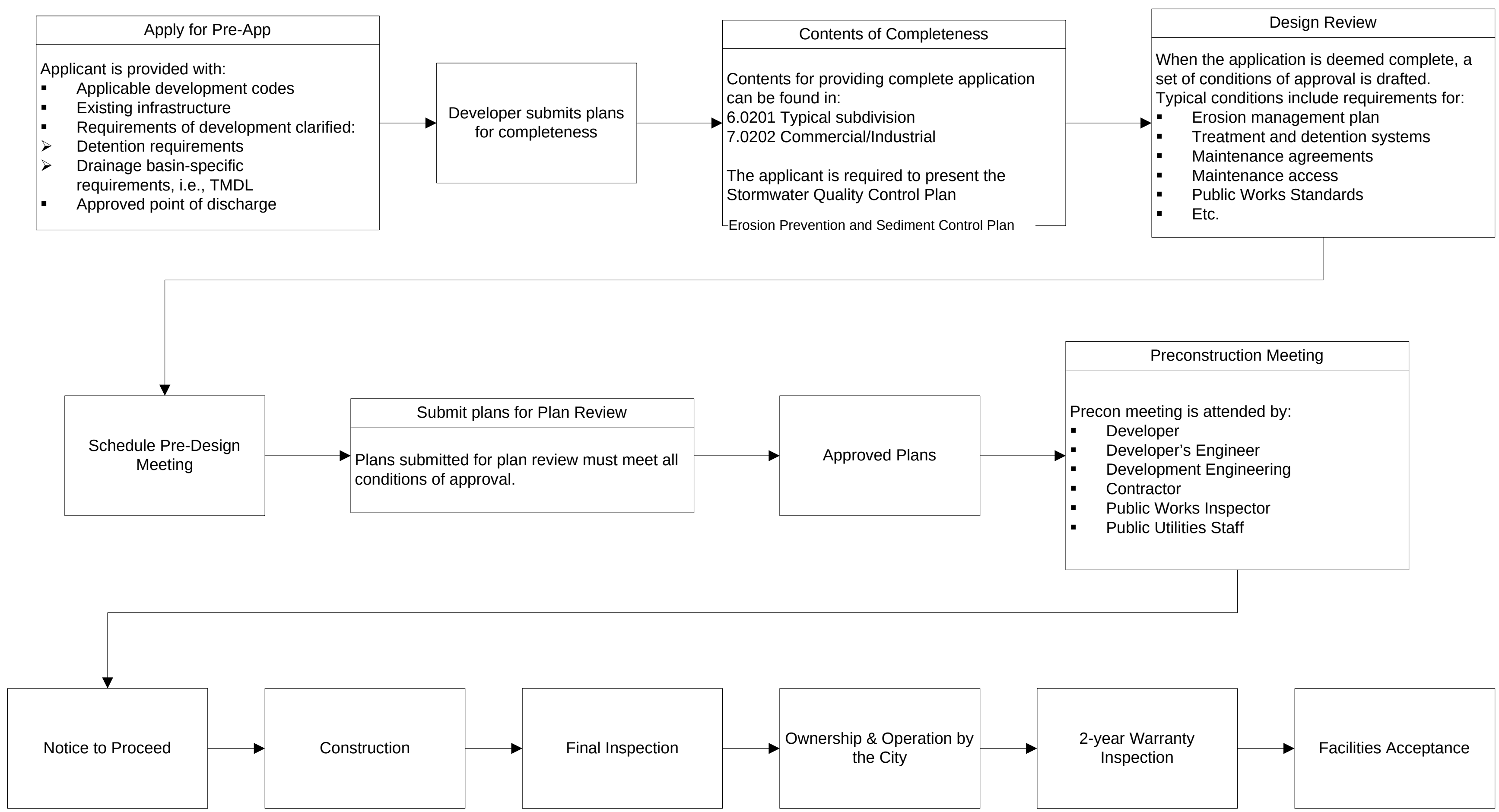
Owners and permittees must ensure their actions do not degrade water quality or harm threatened or endangered species, and shall implement conservation measures to avoid and minimize potential adverse effects.

Refer to the following flow chart titled, "Development Process Overview," to review the City's permit approval process. To review the permit approval process timeline, refer to GDC Section 11.0211 through 11.0217.

Periodic updates to this *Manual* will be made as materials, practices, and policies change within the industry and are made available.

The contents of this *Manual* should not be interpreted as necessarily representing the policies or recommendations of other referenced agencies or organizations. Furthermore, the mention of trade names, products, equipment, or manufacturers is not an endorsement by the City of Gresham. Manufacturer trade names appear here only when considered essential to the educational objectives of the *Manual*.

Figure 1.2.1 Development Process Overview



This Development Review Process flowchart represents a very simplified version of actual process. It is limited to this Manual and is an overview only. It is not meant to replace or supersede other process and/or permitting needs not mentioned but required.

Chapter 2 Single-Family/Duplex Development

2.1 Overview

This chapter describes the requirements for preparing Erosion Prevention and Sediment Control Plans (Plans) for new single-family and duplex construction requiring a building permit.

2.2 Requirements

The city of Gresham's inspection threshold for erosion prevention and sediment control is any disturbance of 500 square feet or more. It is the responsibility of the permit holder to keep sediment on-site. Plans shall describe ways to minimize the discharge of pollutants in runoff from any construction activity, using erosion prevention, and sediment, runoff, and non-stormwater pollution control BMPs.

The City of Gresham does not require that a registered engineer prepare the Plan for single-family/duplex construction, unlike development projects over 20 acres in size.

The Plan designer shall incorporate information and observations obtained from the City, applicable resource agencies, and a site visit. In addition, the designer must identify potential erosion and sediment problems, develop design objectives, formulate and evaluate alternatives, select best erosion prevention measures, and develop a Plan.

The permit holder shall designate a person with erosion prevention and sediment control experience. The designated person, whether contractor or erosion and sediment control specialist, has a defined responsibility to prevent sediment from leaving the site. The designee must follow the Plan, or make approved revisions to the plan as necessary, and ensure that the site is stable. Although a permitted Plan may appear to have addressed all issues, the designer shall adapt the plan during implementation to ensure proper performance.

See Chapter 4 for required maintenance & inspection practices.

The Plan shall be submitted with the building permit application.

2.3 Minimum BMPs for Single-Family / Duplex Projects

Minimum BMPs for single family or duplex permitted projects are listed in Table 2.3.1. Minimum BMPs for all other development are listed in Table 3.4.1.

Note that wet season construction requires augmented protection measures. If planned dry season construction becomes delayed into the next wet season, the Plan must be revised to include at least the minimum wet season BMPs.

TABLE 2.3.1. MINIMUM BMPS FOR ALL SINGLE-FAMILY / DUPLEX PROJECTS

Best Management Practice[1]	Code[2]	Year Around	Wet Season[3]
Linear Barrier and Perimeter Control	SC-1 to SC-7, SC-12	✓	
Storm Drain Inlet Protection	SC-8	✓	
Construction Entrance/Exit Tracking Controls	NS-5/ SC-10	✓	
Non-Soil Stockpile Management	NS-9	✓	
Concrete Management	NS-14	✓	
Inspection and Maintenance	All	✓	
Soil Stockpile Management	EP-22	✓	
Temporary Seeding and Planting/ Permanent Seeding and Planting	EP-5/ EP-6	✓	✓
Non-Stormwater Pollution Controls	NS 1 to NS 17	✓	✓
Slope Breaks for Steep Slopes	SC-5 to SC-7, RC-4	✓	✓

[1] See also Appendix E: Costs and Suppliers for additional information. BMPs not included in this *Manual* may be submitted to the City for consideration.
[2] Codes correspond to BMP details in Chapters 5 and 6 of this *Manual*.
[3] Additional measures required from October 1 to May 31.

2.4 Site Plan Checklist

Table 2.4.1

Site plan must include the following:

☐ Provide the name and phone number of the person(s) responsible for erosion prevention and sediment control on site.

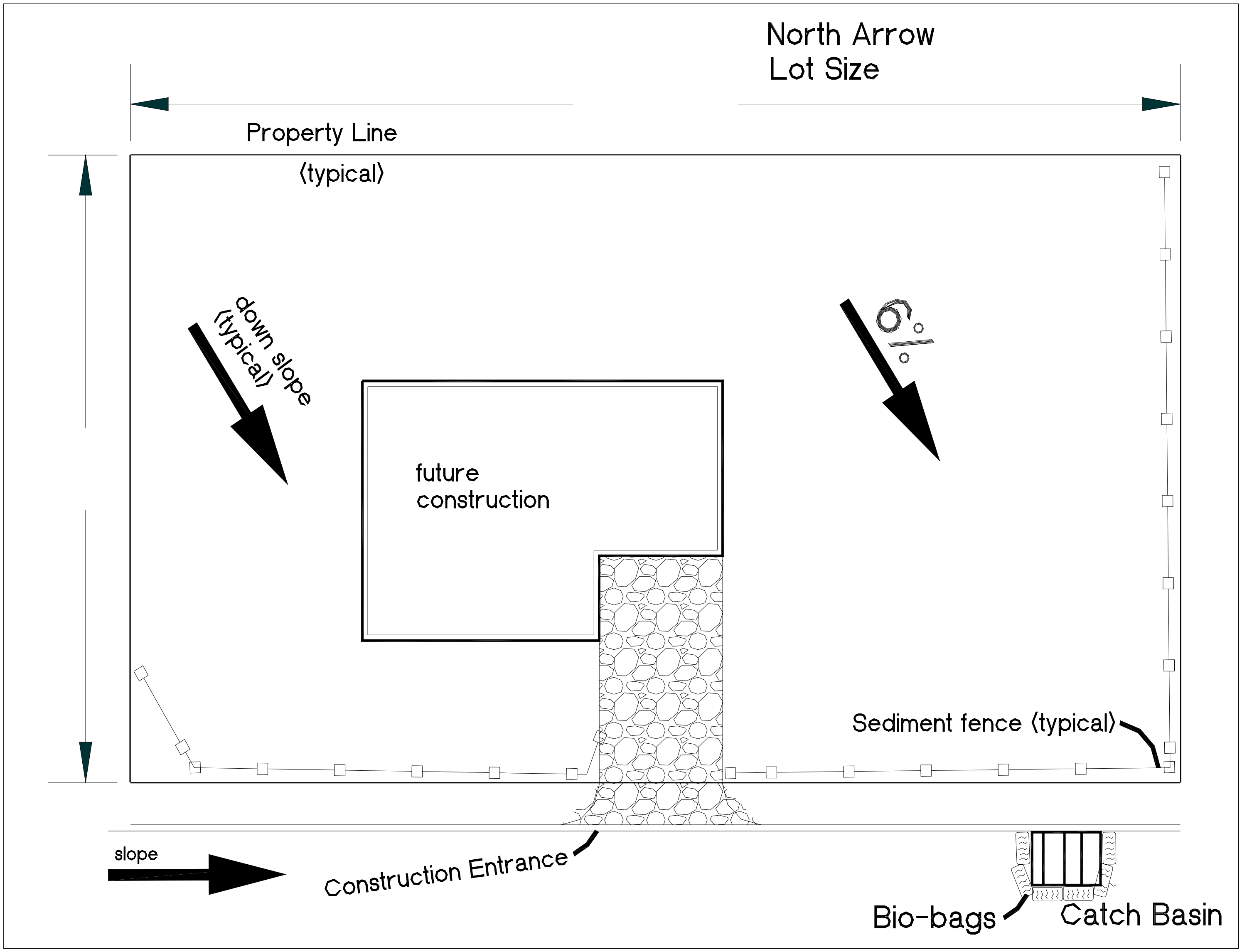
☐ Site contours and/or drainage patterns found on the site—identify any slope greater than 5%.

☐ Location and maintenance schedule of erosion prevention and sediment control measures to be used on site. Including but not limited to:

- Gravel construction entrance
- Sediment barrier: downslope side of the site along contours
- Stormdrain inlet protection

☐ Between October 1 and May 31 notes describing additional wet weather BMPs to be utilized and ground cover.

FIGURE 2.4.1 EXAMPLE SITE PLAN



Chapter 3 All Other Development

3.1 Overview

This chapter describes the requirements for preparing Erosion Prevention and Sediment Control Plans (Plans) for all private and public development projects, except single-family and duplex construction. These projects include new construction on existing lots of record and additions to existing developments that require a City building or grading permit.

3.2 Requirements

The city of Gresham's erosion prevention and sediment control threshold is any disturbance of 500 square feet or more. It is the responsibility of the permit holder to keep sediment on-site. Plans shall describe ways to minimize the discharge of pollutants in runoff from any construction activity, using erosion prevention, and sediment, runoff, and non-stormwater pollution control BMPs.

The City of Gresham requires that all projects include an EPSC Plan. Projects over 20 acres must include a Plan prepared by a registered engineer.

The Plan designer shall incorporate information and observations obtained from the City, applicable resource agencies, and a site visit. In addition, the designer must identify potential erosion and sediment problems, develop design objectives, formulate and evaluate alternatives, select best erosion prevention measures and develop a Plan.

The permit holder shall designate a person with erosion prevention and sediment control experience as the EPSC Manager. The designated person, whether contractor or erosion and sediment control specialist, has a defined responsibility to prevent sediment from leaving the site. The designee must follow the Plan, make approved revisions to the Plan as necessary, and ensure that the site is stable with no visible sediment discharges. Although a permitted Plan may appear to have addressed all issues, the designer shall adapt the Plan during implementation to ensure proper performance.

3.2.1 Standard Notes

The following requirements shall be included on all Plans:

- The owner/permittee, or EPSC Manager, shall be responsible for proper installation, monitoring, maintenance, and removal of all erosion prevention and sediment control measures, in accordance with the city, state, and federal regulations. Responsibility will continue until permanent vegetation or landscape is complete. Owner/permittee shall be responsible for maintenance until the following conditions are met: 1) the project has been accepted by the City; 2) all individual lots are sold; and 3) termination of the 1200-C permit by the Department of Environmental Quality (DEQ).
- Approval of the Plan does not constitute an approval of permanent road or drainage design (e.g., size and location or roads, pipes, restrictors, channels, retention facilities, utilities).
- The boundaries of the clearing limits shown on a Plan shall be clearly marked in the field prior to construction. During the construction period, no disturbance beyond the clearing

limits shall be permitted. The markings shall be maintained by the owner/permittee or designee for the duration of construction.

- The EPSC BMPs shown on the Plan must be constructed in conjunction with all clearing and grading activities, in accordance with the conditions of approval, public works standards, development code, and in such a manner as to ensure that sediment, sediment-laden water, and other pollutants do not enter the drainage system or roadways, or violate applicable water quality standards.
- The EPSC BMPs shown on the Plan are minimum requirements for anticipated site conditions. During the construction period, the BMPs shall be upgraded as needed for unexpected storm events and to ensure that sediment and sediment laden water do not leave the site.
- The EPSC BMPs shall be inspected daily during stormwater and snowmelt runoff and at least once every seven (7) calendar days and within 24 hours after any storm event that produces at least ½ of an inch of rain per 24-hour period. On inactive periods of greater than seven (7) consecutive calendar days, inspections are required every two (2) weeks.
- At no time shall sediment be allowed to accumulate more than one-third the height of any sediment control barrier. Trapped sediments shall be removed from catch basins when design capacity has been reduced by 50 percent. All catch basins and conveyance lines shall be cleaned prior to project final inspection. <u>The cleaning operation shall not flush or intentionally wash sediment-laden water into the downstream stormwater system, streams or drainage ways.</u>
- Sediment that leaves the site shall be cleaned up within 24 hours and placed back on the site or properly disposed. Any in-stream clean up of sediment shall be performed according to requirements of the U.S. Army Corps of Engineers and the Oregon Department of State Lands.
- Storm drain inlets, catch basins, and area drains shall be protected until pavement surfaces are completed and permanent vegetation has been established.
- Stabilized gravel entrances shall be installed at the beginning of construction and maintained for the duration of the project. Additional measures may be required to ensure that all paved areas are kept clean for the duration of the project.
- Concrete washout location shall be provided for washing of concrete trucks and equipment so that concrete slurry is not washed into the stormwater system, streams, or drainage ways. Identify the location on the Plan and include the note: “Do not overfill and bury when finished.”
- Groundcover and/or seeding shall be completed as soon as practicable for each phase of construction and not later than September 1. If fertilizers are used to establish vegetation, the application rates shall follow manufacturer’s guidelines and the application shall be performed in such a way to minimize nutrient-laden runoff to receiving waters. The Plan shall state the conditions for determining successful vegetation establishment.
- Non-stormwater pollutant control measures including any use of toxic or other hazardous materials shall include proper storage, spill containment, application, and disposal.

- Wet weather measures shall be established by October 1st and continue to function through May 31st of the following year. Prior to discontinuing activities on any portion of the site between October 1 and May 31, any exposed area shall be stabilized within 7 days to prevent erosion. Between June 1 and September 30, the site must be stabilized within 30 days. Stabilization may occur by applying appropriate cover (e.g., mulch, erosion control blankets, binders, tackifiers) or establishing adequate vegetative cover.

- Prior to final project acceptance by the City, the site shall be permanently stabilized (seed and mulch or tackifier, or permanent landscaping). See Appendix F: City of Gresham Native Plant Restoration Guide as a resource. For subdivisions, temporary groundcover will be accepted if home construction will begin within 30 days of project finalization.

- The owner/permittee is responsible for removing all sediment control measures once permanent stabilization has been established. DEQ will not terminate the 1200-C permit until permanent vegetation is established.

3.3 Minimum BMPs for All Other Development Projects

Regardless of size or type, the EPSCPs for all projects must contain a minimum set of BMPs. Minimum BMPs for all permitted projects, other than single-family or duplex projects, are listed in Table 3.3.1.

In Gresham, all development projects must contain the minimum BMPs.

Note that wet season construction (Oct 1-May 31) requires augmented protection measures. If planned dry season construction becomes delayed into the next wet season, the Plan must be revised to include at least the minimum wet season BMPs.

The minimum set of BMPs may not be adequate to prevent erosion and sediment discharges under all circumstances and site conditions. In these cases, the designer/builder must select additional BMPs for the Plan to address site-specific conditions. Approved BMPs to address runoff control, erosion prevention, and sediment control are described in Chapter 5.

Approved BMPs to address non-stormwater pollution control are described in detail in Chapter 6.

TABLE 3.3.1. MINIMUM BMPS FOR ALL OTHER DEVELOPMENT PROJECTS

Best Management Practice[1]	Code[2]	Year Around	Wet Season[3]
Linear Barrier and Perimeter Control	SC-1 to SC-7, SC-12	✓	
Storm Drain Inlet Protection	SC-8	✓	
Construction Entrance/Exit Tracking Controls/ Tire Wash, as required	NS-5/ SC-10/ SC-11	✓	
Non-Soil Stockpile Management	NS-9	✓	
Concrete Management	NS-14	✓	
Inspection and Maintenance	All	✓	
Soil Stockpile Management	EP-22	✓	✓
Temporary Seeding and Planting/ Permanent Seeding and Planting	EP-5/ EP-6	✓	✓
Non-Stormwater Pollution Controls	NS 1 to NS 17	✓	✓
Slope Breaks for Steep Slopes (Temporary Interceptor Dikes and Swales)	SC-5 to SC-7, RC-4	✓	✓

[1] See also Appendix E: Costs and Suppliers for additional information. BMPs not included in this *Manual* may be submitted to the City for Consideration.
[2] Codes correspond to BMP details in Chapters 5 and 6 of this *Manual*.
[3] Additional measures required from October 1 to May 31.

Table 3.3.2. PLAN REQUIREMENT CHECKLIST

The EPSC Plan submittal must include:

- ☐ Cover sheet with a site location map.
- ☐ Proposed public and private stormwater system plan or composite utility plan.
- ☐ Final site stabilization or planting plan. (Refer to Appendix D: Conversion and Reference Tables)
- ☐ Completed EPSC plan as noted below.

Site Plan Checklist (Cont.)

The EPSC plan must include the following items:

☐ Name and number of the designated person responsible for erosion control

☐ Contour lines with elevations included on the plan extending 200 feet beyond the property line

☐ Adjacent natural resources, such as, streams, creeks, wetlands, ponds, drainage channels, lakes, and other sensitive areas.

☐ Identification of slopes, drainage patterns, and concentrated flows.

☐ Location of cuts and fills.

☐ Location of excavated materials storage.

☐ Identified clearing limits.

☐ Identified area for concrete truck and equipment cleanout.

☐ Location of gravel construction entrances.

☐ Locations of erosion prevention and sediment control BMPs (refer to Table 3.3.1 for minimum BMP requirements):

1, Sediment control devices, such as, downslope barriers, slope breaks, inlet protection, and outlet protection.

2. Erosion prevention devices, such as, temporary vegetation, matting, mulch, or other appropriate groundcovers.

3. Runoff controls, such as, slope drains, temporary diversions, and check dams.

4. Temporary/permanent detention facilities.

☐ Description of all non-stormwater pollution controls.

Site Plan Checklist (Cont.)

- ☐ Details and/or specifications for all proposed BMPs.
- ☐ Standard notes.
- ☐ BMP maintenance & inspection schedule.
- ☐ Construction schedule.

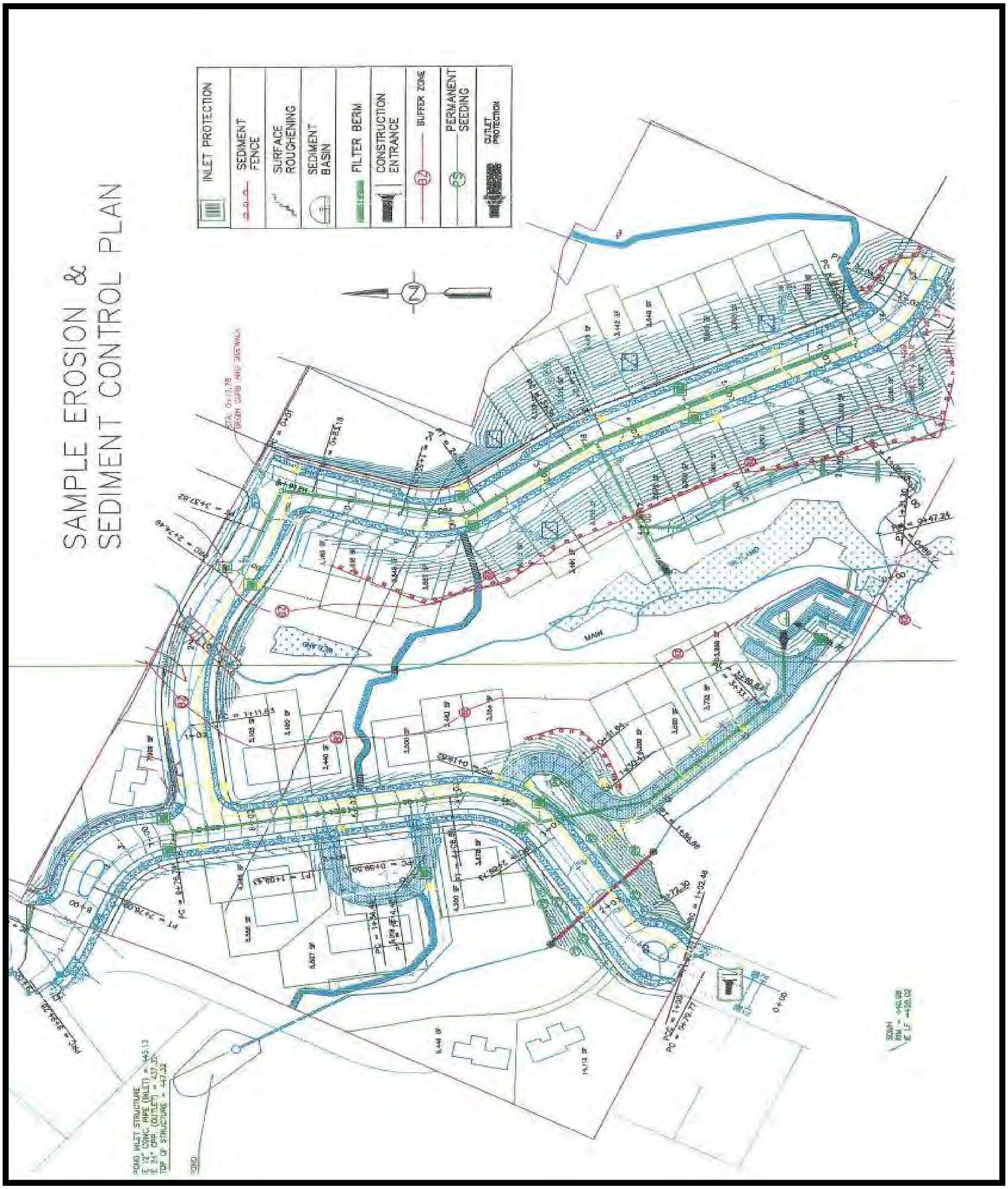
Wet Weather Plan Requirements (October 1 – May 31) must include the following items:

- ☐ Native vegetation, established temporary vegetation, such as seeding and mulch or mulch and tackifier, binders, or matting.
- ☐ Slope stabilization, such as horizontal tracking, terracing, temporary or permanent ground cover, interceptor dikes, or bioswales.

Additional Considerations:

- ☐ Remove the minimum necessary vegetation.
- ☐ Phase construction of the project.
- ☐ Intercept stormwater runoff and direct flow away from exposed soils to a stabilized outlet.
- ☐ Prepare for predicted rain events.

Figure 3.4.2 Sample Site Plan



Chapter 4 Inspection, Maintenance, and Enforcement

4.1 Overview

It is the intent of this chapter to outline the minimum requirements for both the City of Gresham and the Department of Environmental Quality (DEQ) as they pertain to inspection and maintenance. The city's authority to ensure the erosion prevention and sediment control standards are enforced is set forth in the Gresham Revised Code Chapter 7 and Gresham Community Development Code Chapter 2 and 9. These codes are available on the city's website at www.GreshamOregon.gov.

If other regulatory agency rules are violated, the City will notify the appropriate state or federal agency(ies).

This chapter presents site inspection requirements for the NPDES 1200-C General Permit as well as additional standards for conducting an initial site walk-through, vegetation monitoring, and reporting. Unless measures are properly installed and maintained per standards outlined in this section, failure will cause cleanup and restoration costs to escalate.

4.2 EPSC Manager Requirements

The owner/permittee of the site shall designate a person to act as the EPSC Manager. The appointee must be experienced in erosion prevention and sediment control techniques as described in this *Manual*. The EPSC Manager shall be responsible for assuring the implementation of the Plan, as well as having the authority to immediately mobilize necessary personnel and equipment to correct and modify EPSC BMPs when required.

Duties of the EPSC Manager include:

Managing and ensuring proper implementation of the Plan including maintenance and repair of BMPs from both erosion and construction activity.

- Meeting with the City to review and update the Plan and to develop a schedule to ensure that appropriate controls are implemented and maintained during the wet weather periods.
- Ensuring that clearing limits shall be flagged in accordance with the approved EPSC and/or Grading Plan and that no ground disturbance is permitted beyond the flagged boundary.
- Ensuring that flagging is maintained for the duration of construction.
- Ensures the installation of appropriate perimeter control measures prior to any major site grubbing operation. Perimeter control measures include interceptor swales, berms and sediment fences along the outside edge of buffer zones and toes of slope.
- Purchasing, maintaining, and modifying EPSC BMPs as necessary to ensure overall performance is being met.

- Mobilizing crews to make immediate repairs to those measures or install measures during working and non-working hours.
- Recording actions taken to clean up significant amounts of sediment.
- Maintaining an up-to-date Plan throughout the life of the project.
- Overseeing the implementation of wet weather BMPs prior to Oct 1.
- Accompanying the City's representatives or other regulatory agents on inspections.

4.3 Pre-Construction Meeting

The pre-construction meeting provides an opportunity for the contractor to discuss the Plan with the City's inspector and discuss which elements of the Plan warrant the most attention. Adjustments to improve performance or make installation easier and maintenance more reliable may also be discussed. Implementing the Plan and assuring its performance may involve significant expense.

The following activities are required:

- Prior to the pre-construction meeting, review and comment on the Plan.
- During the pre-construction meeting, review all comments and concerns.
- Prohibit clearing and grading operations prior to Plan approval and implementation.
- Delineate clearing limits, drainage courses, easements, setbacks, wetlands, and other sensitive areas and their buffers.

Key points to consider in the pre-construction meeting are:

- Owner/permittee and contractor inspection schedule and procedures.
- Qualifications of the designated EPSC Manager.
- Method to be used to document the up-to-date Plan.
- Adjacent areas that need special protection from sedimentation, such as wetlands, stream crossings, and stormwater outlets.
- Pollution prevention considerations.
- Location of EPSC BMPs and their implementation.
- Sequence of installation with respect to the construction schedule.
- Surface stabilization plans (e.g., temporary and permanent seeding).
- Construction schedule and any anticipated shutdown periods.
- Maintenance plans and the contractor's procedure for monitoring performance.
- Location of all disposal areas.
- Emergency or contingency plans.
- Any special requirements identified in permits.

4.4 Modified EPSC Plan

The City approved Plan is only a guide and may not address all erosion problems for the project adequately. Therefore, it is the responsibility of the owner/permittee or designated EPSC Manager to monitor soil stability on site and propose modifications to the Plan as necessary. In addition, effective erosion control is closely tied to a contractor's staging, operation methods, and construction timing. When the Plan is developed, the contractor's staging and operation methods are unknown. Therefore, it is expected that the Plan will need to be updated throughout the life of the project. As modifications to the Plan take place, it is required to secure the approval of all permitting agencies.

Depending upon the level of modification, the design engineer is responsible for submitting those changes to the City and to DEQ for 1200-C permitted projects. Regardless of its magnitude, a contingency Plan must be implemented immediately. Minor modifications to the Plan, such as installing small sections of sediment control barriers, may be adjusted in the field and hand written, if necessary.

4.5 Construction Schedule Review

The implementation of the construction schedule must include the following:

- Timing of wet weather season work (October 1st through May 31).
- Timing of activities to meet "in-water" work restrictions. (Refer to Department of State Lands for in-water work periods).
- Sediment control measures shown on the plans shall be installed prior to ground-disturbing activities. Interior measures shall be installed as work progresses.
- Permanent facilities, such as detention facilities that will be used as temporary sediment ponds, shall be installed prior to grading.
- Timing of seeding operations.
- Retention of all sediment control measures until disturbed areas have been permanently vegetated or landscaped.

4.6 Inspection Form

Inspections shall be recorded on the Erosion Control Inspection Form (see sample form below). The effectiveness of each BMP at every location on site shall be documented on the form, and general site conditions observations shall be recorded as well. These forms shall be made available to agency staff upon request.

Information provided on the form is useful for tracking repairs and demonstrating permit compliance. It is noteworthy that in the event of permit violations or subsequent enforcement actions, the information recorded on the form, along with photographs and videos may be used to evaluate the responsibility of involved parties.

4.7 Installation

The owner/permittee (or designated EPSC Manager), contractor, and inspector should be familiar with installation details for each BMP used on the project. Details for the installation of all EPSC BMPs shall be included in the Plan. Installation details for BMPs are provided in Chapter 5.

If installed incorrectly, even the best materials will fail, causing more damage and additional expense to the project. For this reason alone, installation procedures should be followed very closely.

Installation of all sediment control measures shall be inspected and any deficiencies corrected prior to the start of land-disturbing activities. Subsequent inspections of any additional installations should also be made throughout the life of the project.

4.8 Operations and Maintenance Guidelines

The selected BMPs shall be operated and maintained consistently with maintenance requirements identified in Schedule A.4 of the NPDES 1200-C General Permit and BMP detail sheets provided in Chapters 5 and 6, and comply with City requirements.

Site-Specific Maintenance and Inspection Instructions

A walk-through or on-site inspection shall be conducted by the EPSC Manager to be certain that all measures have been installed in the field, erosion is being controlled, and transport of sediment into critical areas is being prevented. Deficiencies shall be noted on the EPSC Inspection Form.

Critical inspection points shall be identified to measure performance during storm events. **These critical points include but are not limited to:**

- Outfalls and discharge points
- Slopes that border sensitive areas, such as waterbodies
- Low spots and drainage points at perimeters and at toes of slopes
- Sediment control devices, such as sediment barriers
- Stormdrain inlet protection
- Non-stormwater waste such as building materials, concrete washout stations, hazardous and non-hazardous product storage, litter, and sanitary waste
- Construction site entrance/exit

These critical areas shall be located on a map and prioritized in the BMP maintenance & inspection schedule.

4.9 Inspection Requirements

The owner/permittee or designated EPSC Manager shall provide ongoing inspections of EPSC BMPs throughout the life of the project.

Inspection reports are required for all 1200-C permitted projects. Inspection reports should be kept for a period of three years after completion of final site stabilization and issuance of the notice of termination for the 1200-C NPDES permit by DEQ.

Minimum inspection requirements are:

- Once per week on active sites.
- Once every two weeks on inactive sites.
- Within 24 hours following a ½-inch rain event or greater.
- Each inspection shall be recorded on the EPSC Inspection Form.

The EPSC Inspection Form (Figure 4.9.1) includes the date, inspector's name, weather conditions, observations for all BMP performance, and observations of any discharges and their characteristics (i.e., turbidity, etc.), as required.

Reports shall include information on damages or deficiencies, maintenance or repair activities, and vegetation establishment. Inspection reports must be kept on-site or be maintained by the permittee and made available for agency inspections upon request.

Figure 4.9.1 SAMPLE EROSION CONTROL INSPECTION FORM

PROJECT NAME:			PROJECT #
LOCATION:			RECEIVING WATER:
CONTRACTOR:			
EROSION CONTROL FACILITIES			
LOCATION	DESCRIPTION	EFFECTIVENESS	DATE
VISIBLE OR MEASURABLE EROSION LEAVING SITE LOCATION	CORRECTIVE & CLEAN-UP MEASURES EFFECTIVENESS DATE		
COMMENTS AND GENERAL SITE CONDITIONS:			
PREPARED BY:		PERIOD:	
Minimum Inspection Reporting Requirements: Inspect all erosion control facilities a minimum of once per week on active projects. Inspect within 24 hours following a 0.5-inch rain event. Inspect daily during stormy periods or periods of snow melt when runoff occurs daily. Furnish copy to City or DEQ upon request.			

4.10 Erosion Control Contingency Items

During storm events, the contractor shall be prepared to call out maintenance crews to inspect the performance of erosion and sediment control measures. Following storm events, the contractor shall conduct an overall site inspection and replace or repair damaged control measures.

It is a requirement that all construction sites have materials on hand as a contingency in the event of a failure or when required to shore up BMPs installed as part of the Plan. The contingency items may also be used at the discretion of the project inspector to strengthen the erosion prevention measures as needed during construction.

At a minimum, the following materials should be kept on all active project sites for use in emergencies:

- 100 feet of sediment fence or other identified sediment barrier
- 260 square feet of plastic sheeting
- 1,000 feet of rope
- 50 empty sandbags (to be filled as needed)
- 10 bales of straw (used for ground cover)
- 10 biofilter bags with stakes
- 5 catch basin filter inserts

4.11 Minimum Maintenance Requirements

At a minimum, maintenance shall include: (Refer to 4.9 Inspection Requirements during the wet weather season)

- Sweeping tracked sediment from paved areas.
- Weekly inspection of storm drain inlet protection and sediment removal from and around catch basins in the street and on your property.
- Weekly inspection of sediment barriers shall include: removal of accumulated sediment, retrenching bottom of the sediment fence, and general repair of damaged sections.
- Adding rock to construction entrance to maintain effectiveness.
- Limiting construction traffic to construction driveway and paved areas only.
- Immediate repair of BMPs removed or damaged due to or during construction activity.

Ultimately, preventing erosion and controlling sediment on the construction site is the responsibility of the permit holder.

4.12 Sediment Removal / Disposal

Sediment shall be removed from controls such as sediment fences, sediment barriers, check dams, inlet protection, and sediment traps when the sediment buildup has reached one-third the exposed height of the control or storage depth. Rock filters and filter berm material shall be replaced with new rock material when sediment reduces the filtering capacity by 50 percent. Rock or other material specified shall be added or removed as needed to maintain proper function of the construction entrance areas. All paved areas shall be kept clean (by mechanical means) for the duration of the project.

It is a violation of City Code to release wash water or intentionally wash sediment into the public stormwater system.

In the event of continuous rainfall over a 24-hour period or other circumstances that preclude the operation of equipment where maintenance, sediment removal, or the installation of additional BMPs is necessary, manual labor must be used to ensure site conditions are maintained to ensure water quality protection.

Removed sediment shall be placed in a non-erodible area within the construction site, or removed and disposed of off-site in accordance with all federal, state, and City regulations. Sediment-laden water shall not be flushed into the stormwater system.

4.13 Inspection and Enforcement by the City

4.13.1 Expectations and Penalties

The City of Gresham performs inspections for all construction sites. If any deficiencies are found, the owner/permittee or designated EPSC Manager shall make all corrections requested by the City's inspector (either verbal or written) within the specified timeframe. The city may document site concerns with photographs and/or collecting monitoring samples of site runoff.

Erosion resulting from construction activities must be effectively controlled to keep sediment from leaving the site or the City may limit the amount of disturbed area.

Failure to comply with a written inspection report, verbal direction, or this *Manual* will result in the issuance of a "Notice of Violation" (NOV). Failure to comply with the notice of violation will result in enforcement action that may include one or more of the following: stop work order, abatement, or a civil penalty issued per day per item from the date of the initial NOV; or termination or suspension of City issued permits (e.g., grading, building). The City may also perform a summary abatement without notice if the violation poses an imminent threat to public health and safety.

The choice of enforcement action and the severity of any penalty should be based on the nature of the violation and the damage or risk to the public, environment, or public resources. The specified time frame for compliance after issuance of a Compliance order is generally 24 to 72 hours, however, it is ultimately up to the judgment of the inspector, and is based on the following: (1) the magnitude of the violation; (2) the potential impact to human health or the environment; (3) the violator's past compliance history; (4) cooperative effort to resolve the situation; (5) the weather forecast.

Additionally, sites with 1200-C permits will be referred to DEQ for enforcement action. If previously documented violations are not addressed, the City may utilize the services of erosion prevention and sediment control contractor to bring the site into compliance and the owner/permittee will be billed for the services.

4.13.2 Criteria for Determining Site Compliance

The City may take enforcement action if any of the following criteria are not met:

1) Failure to repair or install BMPs according to the City Inspectors directive (written or verbal) within the specified timeframe.

2) Exceedance of the average daily amount of soil loss predicted by the Revised Universal Soil Loss Equation (RUSLE). (See also Appendix B of this manual.) If one pound or more of sediment (wet weight) yield per acre can be collected from a construction site in a single day, the City may require additional BMPs or levels of BMP implementation at the site.

3) Violation of State Water Quality Turbidity Rule.

4) Failure to respond, contain, or cleanup any other spills or discharges that are capable of polluting stormwater.

Table 4.13.1 Inspection & Maintenance Checklist

This checklist is for use by the EPSC Manager and the City Inspector

Schedule

- ☐ Walk the site during the EPSC Plan development & final process to look for areas of concern, especially sensitive areas.
- ☐ Review schedule to ensure there are no conflicts and that any instream work windows have been accounted for in the overall timeline.
- ☐ Ensure BMPs are installed before earthwork begins.
- ☐ Review project staging schedule to ensure that BMPs are staged accordingly.
- ☐ Ensure that project site has the appropriate and minimum materials on hand to cover each phase of the project. (Refer to Section 4.10).

- ☐ Review inspection schedule frequency to ensure appropriate planning for sensitive areas and the wet weather season.
- ☐ Ensure that seeding will occur by the Sept 1 deadline and that appropriate wet weather BMPs are in place. Review the steps that will be taken to control sediment during earthwork after the seeding deadline.
- ☐ Ensure site is fully stabilized before BMPs are removed.

EPSC Plan

- ☐ Walk the site prior to earthwork to ensure that the Plan is still adequate.
- ☐ Identify where the Plan will be kept on the project site and periodically review to ensure that the Plan is being kept up-to-date.
- ☐ Ensure that a Contingency Plan is in place for unexpected events.
- ☐ Review the steps that will be taken regarding removal and disposal of waste materials (soil, construction debris, etc.), dust control and plans to combat wind erosion with the City Inspector.

Inspection & Maintenance

- ☐ Ensure that catch basins, stormdrain inlets, sediment barriers and check dams are cleaned when sediment reaches 1/3 the volume or storage depth.
- ☐ Ensure BMPs are repaired and properly functioning and that gravel entrances are periodically maintained. Look for signs of erosion on steep slopes (cut/fill areas) and add BMPs if necessary.
- ☐ Ensure finished slopes or other areas are properly stabilized.
- ☐ Identify areas that will benefit from temporary ground cover/rocking of completed roadways, where additional work will be performed at a later date.
- ☐ Inspect filtration devices for maintenance needs, sand filters, chitosan socks, sediments bags.
- ☐ Inspect sensitive areas that require extra attention such as areas with runoff or run-on, low spots at the toe of the slope, and discharge/outfall locations from the site.
- ☐ Inspect all non-stormwater pollutant control BMPs to ensure proper function.

4.14 Vegetation Establishment Criteria

Because vegetation typically is a primary form of permanent erosion control, it is important to ascertain how quickly and how well the vegetation is becoming established. The Plan shall state the conditions for determining successful vegetation establishment. Vegetation shall be monitored at least monthly to evaluate the following:

Appendix D provides additional information for hydraulic application rates.

- The type of vegetation that is growing (as compared to the type of vegetation that was planted or seeded).
- The density of vegetation that is growing, including the percent of ground that is covered.
- Location and type of erosion (such as sheet erosion, rilling, gullying, and localized scour).
- Any instances of unnecessary vegetation removal (root disturbance can greatly increase erosion potential).

Based on regular evaluations of vegetation establishment, recommendations shall be made as to whether the vegetation is establishing well, or whether additional measures must be taken, such as over-seeding, fertilizing, erosion repair, or irrigation. Vegetation monitoring shall continue until the vegetation reaches maturity and is providing the anticipated erosion control effectiveness.

Water quality ponds and swales shall be monitored for vegetation establishment in accordance with the *City of Gresham Water Quality Manual* and the approved Plans to ensure that they are functioning properly.

4.15 Common BMP Installation Mistakes and Maintenance Guidelines

The most frequent causes of BMP failure are lack of preventative practices and poor maintenance of installed BMPs. Erosion prevention and sediment control BMPs must be inspected regularly and operated and maintained using specific procedures to perform properly. Installation mistakes can also impair BMP performance. Inspectors should pay particular attention to BMP maintenance problems and installation mistakes during inspections. Information on BMP installation and maintenance can be found within the BMPs included in Chapters 5 and 6.

4.16 Stabilizing the Site and Terminating the Permit

In order to terminate coverage under the NPDES 1200-C General Permit, the permittee must complete a Notice of Termination (NOT) form and submit it to DEQ. The termination of a 1200-C permit does not relieve the permittee/property owner of other project close-out (final punch list) requirements by the City.

In order for coverage to be terminated, the following conditions must be met:

a) There is no potential for discharge or a significant amount of construction related sediment to surface waters.

b) All elements of the EPSCP must be completed.

c) All temporary erosion and sediment controls as well as construction related materials or wastes must be removed from the site and disposed of properly. This includes any sediment that was being retained by temporary erosion and sediment controls.

d) All disturbed areas of the site must be stabilized.

Additionally, the City's final inspection punch list items shall be completed. Refer to the *City of Gresham Water Quality Manual* for requirements related to water quality facilities.

Retain permit-related documentation (EPSCP, NOI, City inspection reports, etc.) for a period of one year after the permit is terminated, in accordance with the requirements of the NPDES 1200-C General Permit. Erosion Control Monitoring Forms must be kept for a period of three years after completion of final site stabilization.

Chapter 5 Best Management Practices in Detail

5.1 Overview

This chapter provides detailed descriptions of erosion prevention, runoff control and sediment control BMPs to serve as the foundation of an effective Plan. By selecting various types of BMPs, the designer can ensure a properly protected site. City approved BMPs are organized in this chapter within three functional categories:

- Erosion Prevention
- Runoff Control
- Sediment Control

In addition, thorough Plans incorporate measures to control non-stormwater pollution sources, which are presented in Chapter 6.

Critical factors to prevent accelerated erosion:

- ***Minimize the length of time that soils are left exposed.***
- ***Reduce the total area of exposed soil.***
- ***Protect critical areas such as drainage channels, streams, and natural watercourses.***
- ***Stabilize exposed areas quickly.***
- ***Monitor and maintain EPSC measures.***

Designers and builders must consider the need for each BMP category and select the appropriate mix of BMPs for your project using the following principles:

- Fit the project to the existing topography, soils, and vegetation.
- Minimize disturbance and retain natural vegetation.
- Schedule construction to minimize soil exposure during rainy season.
- Vegetate and mulch denuded areas.
- Minimize concentrated flows and divert runoff away from slopes or critical areas.
- Minimize slope steepness and slope length by using benches, terraces, contour furrows, diversion ditches, or other slope breaks.
- Utilize channel linings and check dams or other temporary structures in drainage channels to slow runoff velocities.
- Keep sediment on site by using sediment basins, traps or sediment barriers.
- Monitor and inspect sites frequently and correct problems promptly.

5.2 Erosion Prevention

This section summarizes a wide range of erosion prevention practices, materials and methods to be applied during earthwork activities including BMPs to prevent erosion on graded surfaces, and biotechnical erosion control methods.

5.2.1 Erosion Prevention (EP) BMPs

Erosion prevention is the highest priority in the overall Plan and should be integrated into a project throughout planning, design, scheduling, and during construction itself. Important erosion prevention concepts related to planning, design, and scheduling are discussed in BMP EP-1. Limiting soil disturbance and establishing vegetative buffers prior to construction are discussed in BMP EP-2. However, this chapter focuses on measures to be implemented during earthwork activities to control erosion.

5.3 Runoff Control

This section identifies BMPs to control stormwater runoff and drainage patterns at construction sites. Runoff control measures must be designed into the Plan and implemented during construction. Runoff control practices are BMPs that are designed to control the peak volumes and flow rates and to prevent scour due to concentrated flows. This chapter identifies approved practices to divert and control runoff.

5.3.1 Runoff Control (RC) BMPs

Even the best erosion control system cannot perform adequately without control of run-on and runoff. It is particularly important to control concentrated flow with measures to prevent rilling and scour of exposed soils. These measures must be in place before the start of the rainy season.

Stormwater runoff leaving the site shall not be sediment laden.

At a construction site, runoff conditions must be evaluated both within the site itself as well as along the site perimeter. Within the site, controls must be installed that will reduce flow velocity and prevent rilling and scour. Along the perimeter, controls should be selected based on consideration of run-on from adjacent areas. Clean run-on should be directed away from construction activities and exposed areas to a stabilized location.

5.4 Sediment Control

This section identifies sediment control measures and methods to prevent sediment from moving offsite. The identified BMPs are to be applied prior to and during earthwork. Sediment control is any practice that traps soil particles after they have been dislodged and moved by wind or water. Sediment control measures are usually passive systems that rely on filtering or settling particles out of the water or wind that is transporting them. Sediment control treats the soil as a waste product that must be removed from where it has been transported and accumulated requiring disposal of at another location. Sediment control measures are considered the "last line of defense" before stormwater runoff leaves the site and not a primary pollution control method, such as source controls (runoff control and erosion prevention).

5.4.1 Sediment Control (SC) BMPs

Continuous inspection and maintenance are critical to the success of sediment control BMPs. Sediment control shall be provided along the downslope site perimeter, at all operational internal and adjacent storm drain inlets, and at vehicle access points prior to ground disturbing activities and at all times during construction.

EPSC Details
For Erosion Prevention

SCHEDULING – EP-1

Application: Scheduling involves sequencing construction activities and the installation of erosion prevention and sediment control measures to reduce the amount and duration of soil exposed to erosion by wind, rain, runoff and vehicle tracking. The best way to control the discharge of sediment and related pollutants from a construction site is to prevent erosion from occurring in the first place.

Design Guidelines: The timing of soil-disturbing activities and the timing of implementation of BMPs are both critical to the prevention of accelerated erosion and transport of sediment off-site. The scheduling of grading should take into account the rainy season and shall minimize the length of the time that soils are left exposed, and reduce the total area of exposed soil during the rainy season. Consideration shall be given to phasing the grading and construction so that critical areas (such as highly erodible soils, areas adjacent to receiving waters, etc.) are not disturbed until the non-rainy season, and so the entire area that is disturbed at any one time is kept to a size that can be controlled effectively.

Construction Specifications / Installation:

- The optimum grading period is when the chance for precipitation is minimized (e.g., the non-rainy season), particularly for the critical areas. If precipitation is likely during grading, minimize the length of time that soils are exposed, and the total area of exposure.
- Materials used for erosion and sediment control shall be on site at all times.
- Perform the following actions when precipitation is forecast:
  - Minimize the length of time that the soils are left exposed.
  - Reduce the total area of exposed soil.
  - Protect critical areas such as drainage channels, streams, and natural water courses.
  - Stabilize exposed areas quickly.
  - Ensure inlets are protected and protection measures maintained.
- The schedule shall clearly show how regional precipitation trends relate to soil-disturbing and re-stabilization activities. The construction schedule shall be incorporated into the Erosion Prevention and Sediment Control Plan.
- The schedule shall include detail on the implementation and deployment of temporary soil stabilization measures, temporary sediment controls, tracking controls, wind erosion controls, non-stormwater pollution controls (including waste management and materials pollution controls).
- The schedule shall also include dates for significant long-term operations or activities that may have planned non-stormwater discharges such as dewatering, saw cutting, grinding, drilling, boring, crushing, blasting, painting, hydro-demolition, mortar mixing, bridge cleaning, etc.
- Develop the sequencing and timetable for the start and completion of each item such as site clearing and grubbing, grading, excavation, paving, pouring foundations, installing utilities, etc., to minimize the active construction area during the rainy season.
- Schedule major grading operations when the chances of precipitation are minimized when practical.
- Schedule the installation, removal, or modification of run-on and run-off controls, and flow conveyance structures, for the non-rainy season or when there is a low probability of precipitation to reduce the likelihood of uncontrolled flow across and from the site.
- Stabilize non-active areas after the cessation of soil-disturbing activities or prior to the onset of precipitation in accordance with local requirements.
- Monitor the weather forecast for rainfall.

- When rainfall is predicted, adjust the construction schedule to allow the implementation of soil stabilization and sediment controls and sediment treatment controls on all disturbed areas prior to the onset of rain.
- Be prepared year-round to deploy soil stabilization and sediment control practices. Erosion may be caused during dry seasons by unseasonable rainfall, wind, and vehicle tracking. Keep the site stabilized year-round, and retain and maintain sediment trapping devices in operational condition.
- Sequence trenching activities so that most open portions are closed before new trenching begins.
- Incorporate staged seeding and re-vegetation of graded slopes as work progresses.
- Consider scheduling when establishing permanent vegetation (appropriate planting time for specified vegetation).

Monitoring / Maintenance:

- Verify that work is progressing in accordance with the schedule. If progress deviates, take corrective actions.
- Amend the schedule when changes are warranted.
- Amend the schedule to show updated information on the deployment and implementation of construction site BMPs.

PRESERVATION OF EXISTING VEGETATION / BUFFER STRIPS – EP-2

Application: Maintaining existing vegetation or placing vegetative buffer strips can have numerous benefits for stormwater quality, erosion prevention and sediment control, as well as landscape beautification, dust control, noise reduction, shade and watershed protection.

Design Guidelines: Preservation of existing vegetation and buffer strips shall conform to site conditions, City codes, and permit requirements.

Materials/Equipment: Temporary barrier shall be perimeter fencing or flagging. Fence posts shall either be wood or metal, as appropriate for the intended purpose.

Construction Specifications/Installation:

Timing

- Preservation of existing vegetation shall be provided prior to the commencement of clearing and grubbing operations or other soil-disturbing activities in areas identified on the plans to be preserved, especially on areas designated as environmentally sensitive areas or where no construction activity is planned or will occur at a later date.
- Limits of clearing and grubbing shall be clearly marked prior to any grading or clearing activities.
- Preservation of existing vegetation shall conform to scheduling, City, and permitting agency requirements.

Design and Layout

- Mark areas to be preserved with temporary fencing made of orange polypropylene that is stabilized against ultraviolet light. The temporary fencing shall be at least 3 feet tall and shall have openings not larger than 2 inches x 2 inches.
- The post spacing and depth shall be adequate to completely support the fence in an upright position.
- Minimize the disturbed areas by locating temporary roadways to avoid stands of trees and shrubs and to follow existing contours to reduce cutting and filling.
- Consider the impact of grade changes to existing vegetation and the root zone.
- Construction materials, equipment storage, and parking areas shall be located where they will not cause root compaction.
- Keep equipment away from trees to prevent trunk and root damage at least to drip line.
- Maintain existing irrigation systems.
- Employees and subcontractors shall be instructed to honor protective devices.
- No heavy equipment, vehicular traffic, or storage piles of any construction materials shall be permitted within the drip line of any tree to be retained. Removed trees shall not be felled, pushed, or pulled into any retained trees. Fires shall not be permitted within 100 feet of the drip line of any retained trees. No toxic or construction materials (including paint, acid, nails, gypsum board, chemicals, fuels, and lubricants) shall be stored within 50 feet of the drip line of any retained trees, nor disposed of in any way which would injure vegetation.

Trenching and Tunneling

- Trenching shall be as far away from tree trunks as possible, usually outside of the tree drip line or canopy. Curve trenches around trees to avoid large roots or root concentrations. If roots are encountered, consider tunneling under them. When trenching and/or tunneling near or under trees to be retained, tunnels shall be at least 18 inches below the ground surface, and not below the tree center to minimize impact on the roots.
- Tree roots shall not be left exposed to air; they shall be covered with soil as soon as possible, protected, and kept moistened with wet burlap or peat moss until the tunnel and/or trench can be completed.
- The ends of damaged or cut roots shall be cut off smoothly.
- Trenches and tunnels shall be filled as soon as possible or in accordance with local requirements. Careful filling and tamping will eliminate air spaces in the soil which can damage roots.
- After all other work is complete, fences and barriers shall be removed last. This is because protected trees may be destroyed by carelessness during the final cleanup and landscaping.

Vegetative Buffer Strips

- Vegetated buffer strips (vegetated filter strips, filter strips, and grassed filters) are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. Filter strips function by slowing runoff velocities and allowing sediment and other pollutants (e.g., total and dissolved metals) to settle and partially infiltrate into underlying soils. With proper design and maintenance, filter strips can provide relatively high pollutant removal.
- Designate watercourse buffer-filter strips on the Plan.
- The width of a buffer strip (i.e., flow path length) shall be maximized to the extent feasible, with a 15 feet minimum width. Buffer strips shall be sized in accordance with site conditions, City code, and permit local requirements.

Monitoring / Maintenance:

- Periodically inspect perimeter fencing and flagging and re-establish if damaged or removed.

Common Failures:

- Incorrectly locating vegetation preservation zones on the site.
- New personnel who are unfamiliar with site constraints could accidentally remove vegetation if perimeter controls are not re-established after damage.

SURFACE ROUGHENING – EP-3

Application: Surface roughening involves roughening surface soils by mechanical methods including sheepsfoot rolling, track walking, scarifying, stair stepping, and imprinting. All slopes prepared by surface roughening must meet engineering compaction requirements required by the project design and City grading requirements. This BMP is intended to only affect surface soils and is not intended to compromise slope stability or overall compaction.

Design Guidelines: While smoothly graded cut and fill slopes may be attractive to the eye, they are not beneficial from the standpoints of erosion prevention and the establishment of vegetative cover. Soil roughening is the creation of a soil surface roughness by mechanical means. Roughening is performed parallel to the slope contours and perpendicular to the direction of runoff. The benefits provided by soil roughening are slowing runoff, enhancing infiltration, moderating soil temperature, trapping moisture, and enhancing seed germination and root penetration. This is particularly important on cut slopes. Where the slope is too steep to allow construction traffic to travel parallel to the slope, cleated dozers traveling up and down the slope can produce a satisfactory texture on newly compacted soil. Table EP-3.1 presents comparative effectiveness of various soil roughening techniques along with erosion rates for smooth slopes without track walking.

Materials/Equipment: Means of soil roughening may include:

- Sheepsfoot rolling
- Track walking
- Scarifying
- Stair stepping
- Imprinting

Construction Specifications/Installation:

Cut Slope Roughening

- Stair-step grade or groove the cut slopes that are steeper than 3H:1V.
- Use stair-step grading on any erodible material soft enough to be ripped with a bulldozer. Slopes consisting of soft rock with some subsoil are particularly suited to stair-step grading.
- Make the vertical cut distance less than the horizontal distance, and slightly slope the horizontal position of the "step" in toward the vertical wall.
- Do not make individual vertical cuts more than 2 feet high in soft materials or more than 3 feet high in rocky materials.
- Groove the slope using machinery to create a series of ridges and depressions that run parallel to the slopes contours.

Fill Slope Roughening

- Place on fill slopes with a gradient steeper than 3H:1V in lifts not to exceed 8 inches, and make sure each lift is properly compacted.
- Ensure that the face of the slope consists of loose, uncompacted fill 4-6 inches deep.
- Use grooving or tracking to roughen the face of the slopes, if necessary.

- Do not blade or scrape the final slope face.

Roughening for Slopes to Be Mowed

- Slopes which require mowing activities shall not be steeper than 3H:1V.
- Roughen these areas to shallow grooves by track walking, scarifying, sheepsfoot rolling, or imprinting.
- Make grooves close together (less than 10 inches), and not less than 1 inch deep, and perpendicular to the direction of runoff (i.e., parallel to the slope contours).
- Excessive roughness is undesirable where mowing is planned.

Roughening with Tracked Machinery

- Limit roughening with tracked machinery to soils with a sandy textural component to avoid undue compaction of the soil surface.
- Operate tracked machinery up and down the slope to leave horizontal depressions in the soil. Do not back-blade during the final grading operation.
- Seed and mulch roughened areas as soon as possible to obtain optimum seed germination and growth.

Monitoring / Maintenance:

- Check the seeded slopes for signs of erosion such as rills and gullies. Fill these areas slightly above the original grade, then reseed and mulch as soon as possible.

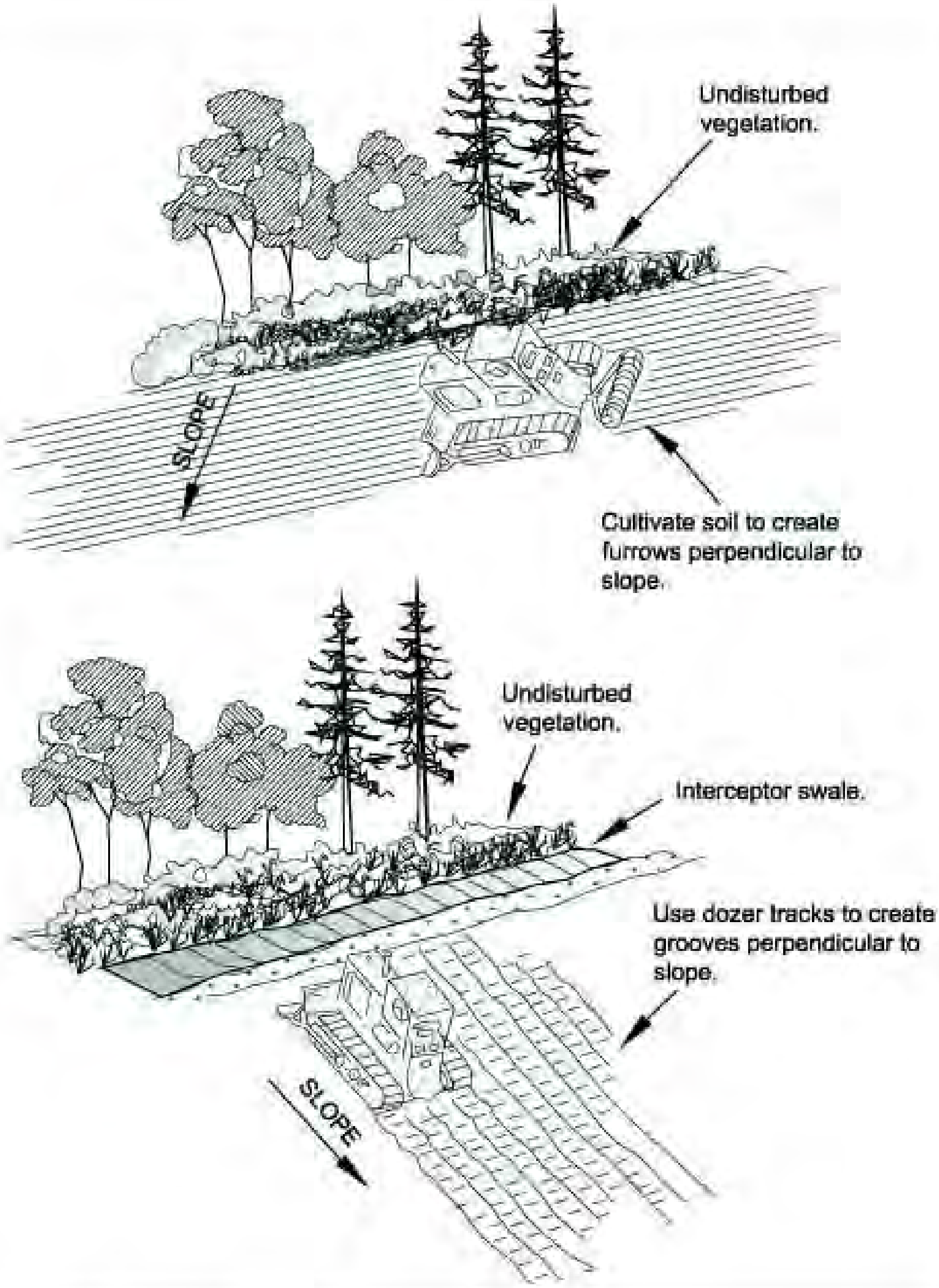
TABLE EP-3.1. RESULTS OF RAINFALL SIMULATION TESTING FOR SOIL ROUGHNESS[1]

Surface Treatment	Measurement	Statistic	Storm Event			Average Increase (+) or Decrease (-) in Roughness
			5-yr	10-yr	50-yr	
Smooth	Normalized Erosion Rate[2]	Mean	0.06-0.07	0.09-0.16	0.09-0.12	
		% of Smooth	100%	100%	100%	0%
	Runoff (L)	Mean	256-364	419-470	422-611	
		% of Smooth	100%	100%	100%	0%
Imprinted	Normalized Erosion Rate[2]	Mean	0.02-0.03	0.02-0.03	0.02-0.03	
		% of Smooth	26-49%	18-25%	19-22%	76% (-)
	Runoff (L)	Mean	222-416	381-447	464-502	
		% of Smooth	87-114%	91-95%	82-110%	4% (-)
Ripped	Normalized Erosion Rate[2]	Mean	0.04-0.07	0.08-0.12	0.06-0.15	
		% of Smooth	66-99%	75-88%	71-121%	12% (-)
	Runoff (L)	Mean	154-276	387-416	374-443	
		% of Smooth	60-76%	89-92%	73-88%	19% (-)
Sheepsfoot	Normalized Erosion Rate[2]	Mean	0.03	0.02-0.05	0.04-0.06	
		% of Smooth	46-58%	14-56%	46-51%	55% (-)
	Runoff (L)	Mean	361-375	512-525	503-584	
		% of Smooth	103-141%	109-125%	96-119%	12% (+)
Trackwalked	Normalized	Mean	0.04	0.04-0.05	0.04-0.07	

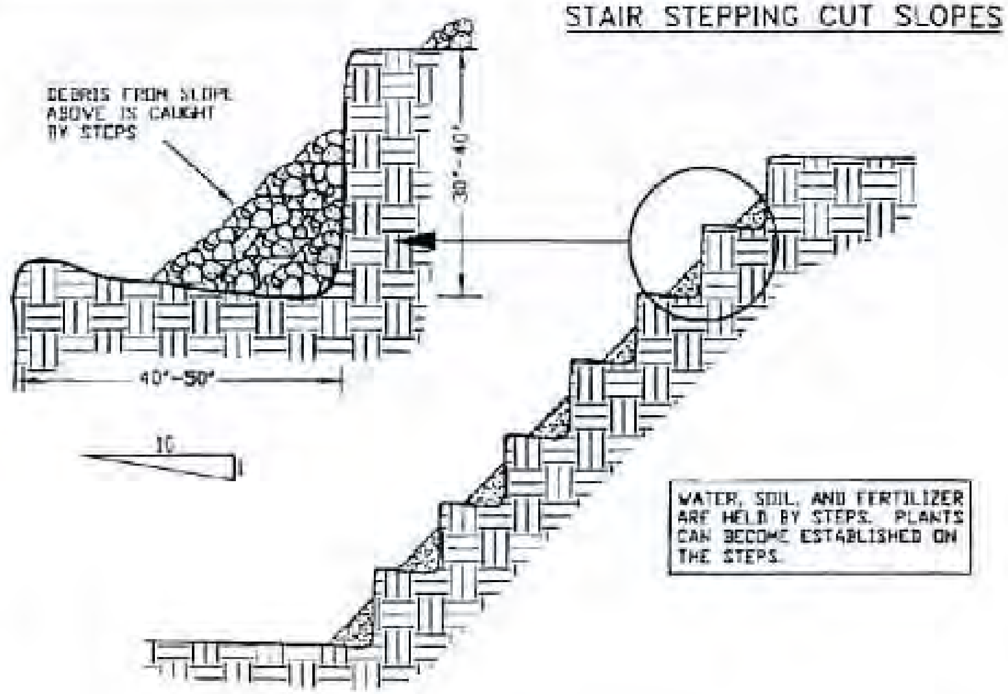
TABLE EP-3.1. RESULTS OF RAINFALL SIMULATION TESTING FOR SOIL ROUGHNESS[1]						
Surface Treatment	Measurement	Statistic	Storm Event			Average Increase (+) or Decrease (-) in Roughness
			5-yr	10-yr	50-yr	
	Erosion Rate[2]	% of Smooth	60-80%	30-40%	30-80%	52% (-)
	Runoff (L)	Mean	219-448	461-468	411-580	
		% of Smooth	86-123%	100-110%	95-97%	2% (+)

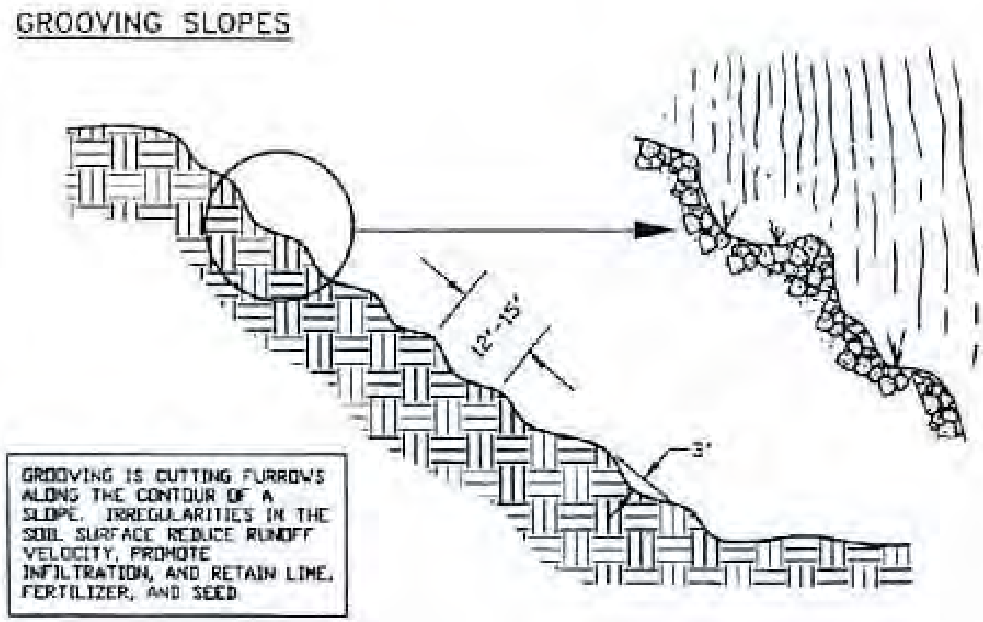
[1] Erosion Control Pilot Study Report, Caltrans, June 2000, Table 4-1. Testing was conducted at the San Diego State University tilting test bed (fill slope) on a 2:1 (H:V) slope using a clayey sand soil.

[2] kg/m2/mm



SURFACE ROUGHENING CAT TRACKING	EP-3





SURFACE ROUGHENING STAIR STEPPING/GROOVING SLOPES	EP-3

TOPSOILING – EP-4

Application: Topsoiling is the practice of stripping and stockpiling existing topsoil and then spreading it in graded areas to encourage future vegetation growth.

Design Guidelines: Determine whether the quality and quantity of available topsoil justifies selective handling and in consideration of City requirements.

Materials/Equipment: Soils of the textural class of loam, sandy loam, and silt loam are best; sandy clay loam, silty clay loam, clay loam, and loamy sand are fair. Do not use heavy clay and organic soils such as peat or muck as topsoil.

Construction Specifications/Installation:

Stripping and Stockpiling

- Strip topsoil only from those areas that will be disturbed by excavation, filling, or compacting by equipment. A 4- to 6-inch stripping depth is common, but depth varies depending on the site.
- Determine depth of stripping by taking soil cores at several locations within each area to be stripped. Topsoil depth generally varies along a gradient from hilltop to toe of the slope.
- Put sediment basins (SC-9), diversions (RC-3 and RC-4), and other controls into place before stripping.
- Select stockpile location to avoid slopes, natural drainage ways, and traffic routes. On large sites, re-spreading is easier and more economical when topsoil is stockpiled in small piles located near areas where they will be used.
- Use sediment fences (SC-1) or other barriers where necessary to retain sediment.
- Protect topsoil stockpiles by temporarily seeding and/or mulching as soon as possible to assure the stored material is not unnecessarily exposed and allowed to erode. Use locally grown and native seed stocks when possible that are mycorrhizal-dependent.
- Topsoil stockpiles shall be low in height ($\leq$3 feet) and flat and be used within 6 months to promote healthy soil organisms and microbes. Stockpiles not used within 6 months shall be reseeded with a species that is mycorrhizal-dependent to avoid the development of anaerobic conditions in the stockpile. In addition, topsoil stockpiles can be turned periodically to keep organisms alive for larger stockpiles and during extremely hot weather.
- For soil stockpile management see BMP EP-22.
- For non-soil stockpile management see BMP NS-9.

Spreading

- Before spreading topsoil, establish erosion and sediment control practices such as diversions, berms (SC-3 and SC-6), dikes, grass-lined channels (RC-5), and sediment basins.
- Where the pH of the existing subsoil is 6.0 or less, or the soil is composed of heavy clays, incorporate agricultural limestone in amounts recommended by soil tests or specified for the seeding mixture to be used. Incorporate lime to a depth of at least 2 inches by disking. Ensure that all of the lime mixture is incorporated into the soil to minimize direct contact with storm water runoff and handle lime in accordance with manufacturing recommendations or BMP NS-7, "Materials Delivery and Storage."

- Immediately prior to spreading the topsoil, loosen the subgrade by disking or scarifying to a depth of at least 3 inches, to ensure bonding of the topsoil and subsoil. If no amendments have been incorporated, loosen the soil to a depth of at least 6 inches before spreading topsoil.
- Uniformly distribute topsoil to a minimum compacted depth of 2 inches on 3H:1V slopes and 4 inches on flatter slopes.
- Do not spread topsoil while it is frozen or muddy or when the subgrade is wet or frozen.
- Correct any irregularities in the surface that result from topsoiling or other operations to prevent the formation of depressions or water pockets.
- Compact the topsoil enough to ensure good contact with the underlying soil, but avoid excessive compacting, as it increases runoff and inhibits seed germination. Light packing with a roller is recommended where high maintenance turf is to be established.

Monitoring / Maintenance:

- Maintain sediment fences, sediment basins, diversions, and other barriers and controls to retain sediment.
- Prevent erosion of stockpiles.

Common Failures:

- Not loosening subgrade.
- Applying too thin a lift of topsoil.

TEMPORARY SEEDING AND PLANTING – EP-5

Application: Temporary seeding and planting consists of the establishment of temporary vegetative cover on disturbed areas to reduce erosion by seeding with appropriate and rapidly growing annual grasses and forbs.

Design Guidelines: Conditions where practice applies:

- Cleared or graded areas that are exposed and subject to erosion for extended periods.
- Cleared or graded areas exposed to seasonal rains.
- Areas that will not be subjected to heavy wear by construction equipment.
- Temporary seeding is encouraged whenever possible to aid in reducing erosion on construction sites. Temporary seeding is an important component of "phased" construction activities. Permanent seeding shall be applied to areas intended to be left dormant for a year or more.

Recorded shear stress protection of grass-covered surfaces is about 100 times greater than bare soil and about the same as surfaces covered by small riprap. Water velocities withstood by grass mixtures and applications are about 2-3 times higher than bare soil.

Seed Species

- Guidance for seed selection can be obtained from the City of Gresham *Water Quality Manual*. The following criteria shall be considered when selecting seed species for establishing vegetation to stabilize disturbed areas on a construction site:
- Satisfaction of the functional requirements of the design.
- Simplicity of appearance and compatibility with the overall landscape.
- Production of extensive root systems.
- Rapidity of establishment.
- Tolerance of site conditions.
- Resistance to insects and diseases.
- Availability from commercial suppliers.
- Ability to self-perpetuate.
- Compatibility with maintenance objectives.
- Selection of species native to the area wherever practical.
- Do not use forbs in roadside seed mixes where there are deer, to avoid animal hazards.

- Do not use lupine adjacent to agricultural or grazing areas, to avoid causing illness to grazing animals.

- Do not use seed mixes that include noxious weed species.

Materials/Equipment: Choose climatically adapted species that are short-lived, hearty and require low inputs of fertilizer, irrigation and mowing. Use locally occurring species for native grass establishment. Consider seed blends because they are more adaptable.

Use seeds appropriate to the season and site conditions. Use seed rates based on minimum pure live seed (PLS) of 80%. When PLS is below 80% adjust rates accordingly. Consult a local seed supplier, landscape architect, or erosion control specialist for appropriate seed blends.

Construction Specifications/Installation:

Site Considerations

- Prior to seeding, install necessary erosion control practices such as temporary continuous berms (SC-6), diversion dikes (RC-3 and RC-4), grass-lined channels (RC-5), and sediment basins (SC-9).

- Proper seedbed preparation and the use of quality seed are important in this practice just as in permanent seeding. Failure to carefully follow sound agronomic recommendations will often result in an inadequate stand of vegetation that provides little or no erosion control.

- Annual plants which sprout rapidly and survive for only one growing season are suitable for establishing temporary vegetative cover. Consider mixes because they are more adaptable than single species.

- Mulch (EP-3) or soil binders (EP-11) shall be used with seeding practices for temporary cover and to aid in the establishment of vegetation.

- Temporary seeding also prevents costly maintenance operations on other erosion control systems. For example, sediment basin maintenance (clean-out) will be reduced if the drainage area has temporary vegetative cover when grading and construction are not taking place. (Temporary seeding is essential to preserve the integrity of earthen structures used to control sediment, such as diversion dikes, and sediment basins.)

- To reduce the amount of fertilizer, pesticides and other inputs needed, choose adapted varieties based on environmental conditions, management level desired, and the intended use. Check with the City prior to use of fertilizer or pesticides.

Timing

- At the onset of inactivity or upon completion of final grading, apply temporary seeding within 7 days during the wet season (October 1st through May 31st) or within 30 days during the dry season (June 1st through September 30th).

- If temporary seeding is applied during the wet season (October 1st through May 31st) additional erosion prevention BMPs shall be implemented until the ground surface is stabilized (e.g., mulch, matting, slope breaks (SC-7)).

- If a healthy stand of grass with at least 80% ground cover is not established by October 1st, other erosion prevention BMPs shall be implemented until the ground surface is stabilized.

- If temporary seeding is applied during the dry season (June 1st through September 30th) or drought periods, irrigate seedbed such that a healthy stand of grass with at least 80% ground cover is established by October 1st.

- The proper time to seed is dependent upon the climate of the area and the species of seed selected. To determine seeding dates for temporary cover, consult the seed supplier.

Seed Mixes

- All seed shall be selected in accordance with City requirements, site conditions, and season.

- Consult a local seed supplier, landscape architect, or erosion control specialist for appropriate seed blends.

- Standard erosion control grass seed mixes are as follows:

  1. **Dwarf Grass Mix (low height, low maintenance)**
     Dwarf Perennial Ryegrass, 80 percent by weight
     Creeping Red Fescue, 20 percent by weight

     - Application rate: 100 lbs/ac minimum

  2. **Standard Height Grass Mix**
     Annual Ryegrass, 40 percent by weight
     Turf-Type Fescue, 60 percent by weight
     Application rate: 100 lbs/ac minimum

  3. **Sterile Wheat Hybrid**

     - *Triticum aestivum × Elytrigia elongata* (Regreen®), 100 percent by weight

     - Application rate: 54 lbs/ac minimum

     - Similar mixes designed to achieve erosion control may be substituted if approved by the City of Gresham.

- The seeding rates are based on a minimum acceptable pure live seed (PLS) of 80%. When PLS is below 80%, adjust rates accordingly.

- Legumes shall be inoculated with the proper rhizobium bacteria before planting. Pellet inoculated seed can be purchased or inoculation can be done in the field. Use only fresh, age-dated inoculate specifically labeled for use with the legume you are using.

Site Preparation

- Grade as needed and feasible to permit the use of equipment for seedbed preparation.

- Install needed erosion control practices, such as sediment basins, diversion dikes and grass-lined channels, prior to seeding. Divert concentrated flows away from seeded areas.

- Soil tests shall be done to determine the nutrient and pH content of soil. Depending on the results of soil tests, soil management may be necessary to adjust the pH to between 6.5 and 7.0 (for most conditions). All lime, fertilizer and other soil amendments shall be added following sound soil management practices.

- Soil amendment: Following a project that exposes subsoils, soils shall be amended to provide suitable conditions for revegetation. Plant life and water absorption capability require similar soil conditions: loose, friable soil with the right balance of organic matter, microorganisms, and minerals. Amendments to consider include topsoil (EP-4), compost, fertilizer, and mycorrhizal fungi and biofertilization (EP-7).

Organic content of amended topsoil shall not exceed 10% for planting beds or 5% for turf areas. Compost in thicker applications (i.e., over 4 inches) provides resistance to weed growth. Organic compost must be certified weed-free.

Commercial fertilizers are labeled to document the ratio of nitrogen (N), phosphorus (P), and potassium (K) (usually listed in order: N-P-K). Fertilizer is applied in various combinations (for example, 20-20-20 or 10-15-5), as determined to be necessary by the results of a soil analysis.

- Surface roughening: If the area has been recently loosened or disturbed, no further roughening is required. When the area is compacted, crusted or hardened the soil shall be loosened with discing, raking or harrowing. Tracking with bulldozer cleats is very effective on sandy soils.

- Hydroseeding and hydraulic planting generally require less seedbed preparation.

- Generally, slopes steeper than 2H:1V that cannot have good seedbed preparations with equipment will require hydraulic planting techniques.

- Seed to soil contact is the key to good germination. Prepare a 3-5 inch deep seedbed, with the top 3-4 inches consisting of topsoil. Note that the earth bed upon which the topsoil is to be placed shall be at the required grade.

- The seedbed shall be firm but not compact. The top 3 inches of soil shall be loose, moist and free of large clods and stones. For most applications, all stones larger than 2 inches diameter, roots, litter and any foreign matter shall be raked and removed. The topsoil surface shall be in reasonably close conformity to the lines, grades and cross sections shown on the grading plans.

Planting

- Seed shall be applied as soon after seedbed preparation as possible, when the soil is loose and moist.

- Always apply seed before mulch, unless seed is applied with a hydraulic matrix or bonded fiber matrix (BFM).

- Apply seed at the rates specified using calibrated spreaders, cyclone seeders, mechanical drills, or hydroseeders so the seed is applied uniformly on the site.

- For hydroseeding, use hydraulic equipment that continuously mixes and agitates the slurry and applies the mixture uniformly through a pressure-spray system providing a continuous, non-fluctuating delivery. Ensure the equipment and application method provide a uniform distribution of the slurry. Place seed (fertilizer, mulch, and tackifier) in the hydroseeder tank no more than 30 minutes prior to application. Perform hydroseeding in a one-step or two-step process.

- Two-step operation (preferred). Step 1 - Apply seed, fertilizer, and tracer (separately or together). Step 2 - Apply mulch and tackifier.

- One-step operation. Apply seed, fertilizer, mulch, tackifier, and tracer in one step. When using the one-step process, double the amount of seed (to compensate for seed suspended above soil by the mulch).

Uniformly apply at the rate specified. Add 500 lbs/ac of hydromulch fiber to the seed and fertilizer mixture to visibly aid uniform application.

- If seed is applied with a bonded fiber matrix, apply BFM from multiple directions to adequately cover the soil. Application from a single direction can result in shadowing, uneven coverage, and failure of the BFM.

- Apply fertilizer if required. Fertilizer used within 50 feet of water bodies or wetlands shall be low-phosphorus fertilizer. Seed and fertilizer shall be incorporated into the soil by raking or chain dragging, or otherwise floated, then lightly compacted to provide good seed-soil contact.

- Straw mulch, erosion control blankets (EP-8) or mulch and tackifiers/soil binders (EP-11) shall be applied over the seeded areas.

Monitoring / Maintenance:

- Newly seeded areas need to be inspected frequently to ensure the grass is growing. Areas that fail to establish cover adequate to prevent sheet and rill erosion will be reseeded as soon as such areas are identified. Spot seeding can be done on small areas to fill in bare spots where grass did not grow properly.

- If the seeded area is damaged due to concentrated runoff, additional practices may be needed.

- Temporary vegetated areas will be maintained until permanent vegetation or other erosion control practices can be established.

Common Failures:

- Insufficient moisture.

- Weather too hot or too cold.

- Poor seed viability.

- Weed invasion.

PERMANENT SEEDING AND PLANTING – EP-6

Application: Permanent seeding establishes a permanent vegetative cover that will prevent soil detachment by raindrop impact, reduce sheet and rill erosion, and stabilize slopes and channels. Permanent seeding can be used in conjunction with erosion control blankets and mats to provide both temporary and permanent erosion prevention controls. Perennial grasses, when used with turf reinforcement mats, provide a fibrous root network that anchors the channel lining. These treatments can greatly increase the maximum permissible velocities are useful in stabilizing channels and grass-lined channels. Perennial grasses and legumes improve wildlife habitat and improve aesthetics.

The potential for erosion will exist during the establishment stage. Failure to carefully follow sound plant establishment recommendations will often result in an inadequate stand of vegetation that provides little or no erosion control.

Specific guidelines for installing sod can be found in EP-21.

Planting of shrubs, trees, and container plants shall be conducted in accordance with specific project landscaping specifications and City of Gresham *Water Quality Manual*.

Design Guidelines: The use of native, indigenous, or naturally-occurring grasses is recommended for biotechnical works. These "native" grasses have evolved in a manner that will not compete with or preclude the establishment, or natural recruitment, of naturally-occurring woody vegetation. Establishment of permanent vegetation provides natural erosion prevention and sediment control by trapping particulates, slowing runoff velocities and enhancing infiltration. Permanent vegetation also is beneficial for long-term aesthetics and wildlife habitat.

Conditions where practice applies:

- Graded, final-graded or cleared areas where permanent vegetative cover is needed to stabilize the soil. Permanent seeding with perennial grasses is recommended when fibrous and deeply rooted are needed to provide slope and soil reinforcement.

- Slopes designated to be treated with erosion control blankets shall be seeded first.

- Grass-lined channels or waterways designed to be treated with turf reinforcement mats, fiber roving systems, or other channel liners require special grass blends.

Seed Species

Guidance for seed selection can be obtained from the City of Gresham *Water Quality Manual*. The following criteria shall be considered when selecting seed species for establishing vegetation to stabilize disturbed areas on a construction site:

- Satisfaction of the functional requirements of the design.

- Simplicity of appearance and compatibility with the overall landscape.

- Production of extensive root systems.

- Rapidity of establishment.
- Tolerance of site conditions.
- Resistance to insects and diseases.
- Availability from commercial suppliers.
- Ability to self-perpetuate.
- Compatibility with maintenance objectives.
- Selection of species native to the area wherever practical.
- Do not use forbs in roadside seed mixes where there are deer, to avoid animal hazards.
- Do not use lupine adjacent to agricultural or grazing areas, to avoid causing illness to grazing animals.
- Do not use seed mixes that include noxious weed species.

Materials/Equipment: Choose climatically adapted perennial species that are long-lived, hearty and require low inputs of fertilizer, irrigation and mowing. Use locally occurring species for native grass establishment. Consider seed blends because they are more adaptable.

Use seeds appropriate to the season and site conditions. Use a seed blend that includes annuals, perennials and legumes. Legumes shall be inoculated with the proper rhizobium bacteria before planting. Pellet inoculated seed can be purchased or inoculation can be done in the field. Use seed rates based on minimum pure live seed (PLS) of 80%. When PLS is below 80% adjust rates accordingly. Consult a local seed supplier, landscape architect, or erosion control specialist for appropriate seed blends.

Construction Specifications/Installation:

Installation

The probability of successful plant establishment can be maximized through good planning, knowledge of soil characteristics, selection of appropriate seed blends for the site, good seedbed preparation, and timely planting. Prior to seeding, install necessary erosion control practices such as diversion dikes (RC-3 and RC-4), grass-lined channels (RC-5), and sediment basins (SC-9). Site area shall be at final grade and not be disturbed by future construction activities.

Timing

- All permanent seeding applications must be completed prior to September 1. If a healthy stand of grass with at least 80% ground cover is not established by October 1st, other erosion prevention BMPs shall be implemented until the ground surface is stabilized.
- If seeding is applied during the dry season (June 1st through September 30th) or drought periods, irrigate seedbed such that a healthy stand of grass with at least 80% ground cover is established by October 1st.

- Apply permanent seeding before the wet season (October 1st through May 31st) or before freezing weather is anticipated.

- Apply permanent seeding on areas left dormant for 1 year or more.

- Apply permanent seeding when no further disturbances are planned.

- To determine optimum seeding schedule, consult a local agronomist, landscape architect, or erosion control specialist.

- Use dormant seeding for late fall or winter seeding schedules in conjunction with other erosion prevention BMPs such as mulches (EP-8), compost blankets (EP-9), soil binders (EP-11), or matting (EP-10).

Seed Mixes

- All seed shall be selected in accordance with City requirements, site conditions, and season.

- Consult a local seed supplier, landscape architect, or erosion control specialist for appropriate seed blends.

- Use only native species within 150 feet of streams and wetlands.

- Use a seed blend that includes annuals, perennials, and legumes.

- Use seed rates based on pure live seed (PLS) of 80%. When PLS is below 80%, adjust rates accordingly.

Site Preparation

- Bring the planting area to final grade and install the necessary erosion control BMPs (e.g., sediment basins and temporary diversion dikes).

- Divert concentrated flows away from the seeded area.

- Conduct soil test to determine pH and nutrient content. Roughen the soil by harrowing, tracking, grooving or furrowing.

- Apply amendments as needed to adjust pH to 6.0-7.5. Incorporate these amendments into the soil. Prepare a 3-5 inch deep seedbed, with the top 3-4 inches consisting of topsoil. The seedbed shall be firm but not compact. The top 3 inches of soil shall be loose, moist and free of large clods and stones. The topsoil surface shall be in reasonably close conformity to the lines, grades and cross sections shown on the grading plans.

- Soil amendment: Following a project that exposes subsoils, soils shall be amended to provide suitable conditions for revegetation. Plant life and water absorption capability require similar soil conditions: loose, friable soil with the right balance of organic matter, microorganisms, and minerals. Amendments to consider include topsoil (EP-4), compost, fertilizer, and mycorrhizal fungi and biofertilization (EP-7).

- Organic content of amended topsoil shall not exceed 10% for planting beds or 5% for turf areas. Compost in thicker applications (i.e., over 4 inches) provides resistance to weed growth. Organic compost must be certified weed-free.

- Commercial fertilizers are labeled to document the ratio of nitrogen (N), phosphorus (P), and potassium (K) (usually listed in order: N-P-K). Fertilizer is applied in various combinations (for example, 20-20-20 or 10-15-5), as determined to be necessary by the results of a soil analysis.

Planting

- Seed to soil contact is the key to good germination.

- Seed shall be applied immediately after seedbed preparation while the soil is loose and moist. If the seedbed has been idle long enough for the soil to become compact, the topsoil shall be harrowed with a disk, spring tooth drag, spike tooth drag, or other equipment designed to conditions the soil for seeding.

- Harrowing, tracking or furrowing shall be done horizontally across the face of the slope.

- Always apply seed before applying mulch, unless using a hydraulic matrix or bonded fiber matrix where seed is mixed with mulch prior before application.

- Apply seed at the rates specified using calibrated seed spreaders, cyclone seeders, mechanical drills, or a hydroseeder so the seed is applied uniformly on the site.

- Broadcast seed shall be incorporated into the soil by raking or chain dragging, and then lightly compacted to provide good seed-soil contact.

- For hydroseeding, use hydraulic equipment that continuously mixes and agitates the slurry and applies the mixture uniformly through a pressure-spray system providing a continuous, non-fluctuating delivery. Ensure the equipment and application methods provide a uniform distribution of the slurry. Place seed (fertilizer, mulch, and tackifier) in the hydroseeder tank no more than 30 minutes prior to application. Perform hydroseeding in a one-step or two-step process.

- Two-step operation (preferred). Step 1 - Apply seed, fertilizer, and tracer (separately or together). Step 2 - Apply mulch and tackifier.

- One-step operation. Apply seed, fertilizer, mulch, tackier, and tracer in one step. When using the one-step process, double the amount of seed (to compensate for seed suspended above soil by the mulch).

- Uniformly apply at the rate specified. Add 500 lbs/acre of hydromulch fiber to the seed and fertilizer mixture to visibly aid uniform application.

- Apply fertilizer as specified and allowed by City. Fertilizer used within 50 feet of water bodies or wetlands shall be low-phosphorus fertilizer. For an alternative to fertilizers, see Mycorrhizae and Biofertilizers (EP-7).

- Apply mulch, compost blankets, or matting as specified, over the seeded areas.

Monitoring / Maintenance:

- Newly seeded areas need to be inspected frequently to ensure the grass is growing.
- If the seeded area is damaged due to runoff, additional stormwater measures shall be applied.
- Spot seeding can be done on small areas to fill in bare spots where grass did not grow properly.
- Irrigation/watering shall be used as necessary to maintain healthy vegetation.

Common Failures:

- Insufficient moisture.
- Weather too hot or too cold.
- Poor seed viability.
- Weed invasion.
- Competition from temporary seeding.

MYCORRHIZAE AND BIOFERTILIZERS – EP-7

Application: Mycorrhizae and biofertilizers are very important to any revegetation effort, as they help to rebuild the living soil that can get damaged by any earthwork. Most desirable species will have a very difficult time out competing weeds without mycorrhizae, or the slowly released nutrients provided by biofertilizers.

Mycorrhizal Fungi. Mycorrhizal fungi form a bridge between the roots and the soil, gathering nutrients from the soil and giving them to the roots. There are two major types of mycorrhizae: ectomycorrhizal fungi (EM) and endomycorrhizal (arbuscular) fungi (AM). While both types penetrate the plant roots, ectomycorrhizae spread their hyphae between root cells, while endomycorrhizae hyphae penetrate root cells. Ectomycorrhizae hosts include members of the *Pinaceae* (Pine family) and *Fagaceae* (Oak and Beech family), as well as few others in scattered families, and involves a "higher" (often mushroom-forming) fungus. EM-dominated forests tend to be low in species diversity compared to arbuscular (AM) forests, and have a thick layer of organic debris on the forest floor.

Endomycorrhizae are the most common, and are found in grasses, shrubs, trees including redwood and cedar, most domestic plant species and many other members of the forest understory. EM fungi are usually specific to a certain host species, but most species of endomycorrhizae will form relationships with almost any AM host plant, and is therefore much easier to specify. There are four major plant families that usually do not form mycorrhizae: *Amaranthaceae* (Pigweed family), *Brassicaceae* (Mustard family), *Chenopodiaceae* (Goosefoot family), and *Zygophyllaceae* (Caltrop family). These plant families are well known as weeds. Therefore, if you do not ensure an adequate supply of mycorrhizae, you may inadvertently inhibit growth of desirable species and allow for rapid growth of undesirable species.

Biofertilizers. Biofertilizers are fertilizers containing living microorganisms, which increase microbial activity in the soil. Often, organic food is included to help the microbes get established.

Soils need nitrogen, phosphorus, and potassium in order to produce healthy plants. Biofertilizers are alternatives to chemical fertilizers (N-P-K). Applying biofertilizers, which are readily available from a variety of soil conditioner manufacturers, increases microbial activity in soil. With biofertilizers, soil fertility is increased by bacteria that fix nitrogen from the air into chemicals that aid plant growth, such as nitrate or ammonia. Microbes can also improve the structure of the soil through secretions that make the soil particles stick together, forming larger particles and thus increasing soil porosity. Microbes also benefit plants by providing a natural defense against soil-borne diseases or pathogens.

Although chemical fertilizers have their benefits, there are certain characteristics offered by biofertilizers that the typical N-P-K fertilizers cannot match. Therefore, the chemical approach may be economical in the short term, but biofertilizers may be less expensive in the long term.

Important functions of soil microbes:

- Convert ambient nitrogen into forms that the plants can use (nitrate and ammonia).
- Increase soil porosity by gluing soil particles together.
- Defend plants against pathogens by out-competing pathogens for food.
- Saprophytic fungi in the soil break leaf litter down into usable nutrients.

The high soil porosity (large spaces between soil particles) caused by microbes is important because it aids water infiltration. If pore spaces are too small, they cannot break the surface tension of a water droplet, and water will run off, instead of saturating the soil, where it can be taken up by plant roots.

The best approach may be to combine both chemical fertilizers and biofertility. A combination of chemical fertilizers and biofertilizers gives the plants a jump-start and maintains them until the microbes can get established.

Design Guidelines: Relationships between mycorrhizal fungi and biofertilizers:

Plant roots secrete food for bacteria and fungi, which attracts nematodes (worms) to the roots. Nematodes eat bacteria and fungi, and excrete nitrogen, sulphur and phosphorus in a form that the plants can use. The nematodes only keep 1/6 of the nitrogen that they process–5/6 is excreted to the plant. Once the nematodes have excreted the nutrients, the hyphae of the mycorrhizal fungi pick them up and transfer them into the plant. Bacteria are the most nitrogen-rich organisms on earth, and bacteria and fungi are the least-leachable forms of nitrogen because of these symbiotic relationships.

However, AM hyphae pick up more nutrients than just those excreted by nematodes. One of the most beneficial properties of AM mycorrhizae is its ability to "mine" the soil great distances from the roots for nutrients, especially those, such as phosphorus, that are poorly mobile in the soil. AM mycorrhizae also assist in picking up water further away from the roots, and block pest access to roots.

Mycorrhizae also benefit plants indirectly by enhancing the structure of the soil. AM hyphae excrete gluey, sugar-based compounds called Glomalin, which help to bind soil particles, and make stable soil aggregates. This gives the soil structure, and improves air and water infiltration, as well as enhancing carbon and nutrient storage.

Most natural, undisturbed soils have an adequate supply of mycorrhizae for plant benefits; however, the following practices can reduce mycorrhizae populations to inadequate levels:

- Erosion
- Grading
- Excavation
- Occupation with non-mycorrhizal plants (weeds)
- Loss of original topsoil

The best way to be sure that appropriate mycorrhizal levels exist in soil onsite is to get a soil sample analyzed for mycorrhizal presence. To maintain healthy mycorrhizae populations:

- Do not apply too much phosphorus, as high levels will limit mycorrhizal effectiveness, low to moderate levels, or slow-release phosphorus will maximize plant benefits.
- Limit fungicide use, as some fungicides damage AM fungi.
- Limit soil disturbance, as disruption of the hyphae in the soil limits water and nutrient movement into the root.
- Consult a landscape architect or agronomist for soil sampling guidance, laboratory selection, and product selection as necessary.

Materials/Equipment: See section entitled, "Application."

Construction Specifications/Installation:

Endomycorrhizae shall be applied at a rate of 3,600,000 propagules per acre, which equates to 60 lbs per acre or 1.4 lbs/1000 ft^2. Mycorrhizae is most frequently applied via hand seeding, seed drilling, hydroseeding, broadcast and till, planting, or as a nursery medium. If installing container plants, packets of mycorrhizae may be planted along with the plant, at a rate of 1 packet per foot of plant height or container width.

Apply biofertilizer based on soil test results, or at the rate recommended by the manufacturer.

Monitoring/Maintenance:

No maintenance should be necessary, although if plants do not appear to be growing vigorously, analysis of mycorrhizal density in the soil can help to determine if you need to apply more.

MULCHES – EP-8

Application: Mulching is the process of applying bulk materials to the soil surface to reduce rainfall impact, increase infiltration and, in some cases, aid in revegetation. Common types of mulch include vegetable fibers, green material, hydraulic mulches from recycled paper or wood fibers, hydraulic matrices (EP-11), straw mulch, and compost blankets (EP-9). Their use and relative longevity is variable. Mulches may include a tackifier to increase the longevity of the application. Mulches function by:

- Moderating soil temperature.
- Reducing soil moisture loss through evaporation.
- Protecting the soil surface from compaction and increasing infiltration.
- Reducing weed competition for desirable plants.
- Armoring the soil against rain drop impact and sheet erosion from runoff.

Design Guidelines: Some typical uses for mulches are:

- As a non-vegetated cover on disturbed sites to temporarily prevent erosion until permanent vegetation can be established.
- In conjunction with seed and soil amendments to establish temporary or permanent vegetative cover.
- To add organic matter, fertility, and improve structure of poor soils.
- As a long-term, non-vegetative ground cover, usually around existing plants, such as trees or shrubs.

Materials/Equipment: See Table EP-8.1 for comparative selection criteria. Some common types of organic mulch are:

- Plant fibers (i.e., straw).
- Composted organic materials/green material (EP-9).
- Hydraulic mulches made from wood fiber or recycled paper (EP-11).
- Erosion control blankets and mats (EP-10).
- Hydraulic matrices (combinations of fibers and adhesives) (EP-9).
- Onsite wood grindings and chipping will only be considered on a site-by-site basis. Generally, grindings will only be considered for slopes less than 5% and on slopes not to receive permanent vegetation.

Plant Fiber Mulches: Plant fibers such as straw mulch must be anchored in place either by punching or crimping them into the soil surface, or by holding them in place with a hydraulically-applied adhesive. The standard application rate for this practice is 2 tons/acre (4,000 lbs/acre) of the straw so that 80-90% of the ground is covered.

Composted Organic Materials/Green Material: Composted organic materials or green materials act as mulches, but have a primary function as soil amendments.

Hydraulic Mulches: Hydraulic mulches and hydraulic matrices are applied using standard hydraulic seeding equipment. The equipment usually consists of a large water tank with some form of agitator which enables the operator to mix seed, soil amendments, and mulch in the tank, and a pump. The pump pushes the resulting slurry through a hose or cannon mounted on top of the machine for application on the soil surface.

When using hydraulic techniques there are requirements for successful vegetation establishment:

- Selection of proper seed mixture adapted to the climate that meets project and City requirements.
- Proper usage of soil amendments and/or biostimulants (EP-7) to enhance soil fertility.

TABLE EP-8.1. COMPARATIVE SELECTION CRITERIA—MULCHING BMPs

Surface Mulch Category	Unit Cost Installed	Estimated Relative Erosion Control Effectiveness	Standard Application Rate	Ease of Installation	Longevity/ Degradability
Hydraulic Mulching Types: Wood, paper, cellulose fiber	$900–1,200/ac	50 – 60%	2,000 lbs/ac	2	6 mo
Compost Application	$900–1,200/ac	40 – 50%	(1 inch blanket application)	3	6 mo
	$7,000-10,000/ac	95 - 99%	(2 inch blanket application)	3	12 mo
	$10,000-15,000/ac	95 - 99%	(3 inch blanket application)	3	12-18 mo
Straw Mulching Types: Rice and wheat	$1,800–2,100/ac	90 – 95%	2 tons/ac	3	6 mo
Wood Chip Types: Blanket	$900–1,200/ac	Unknown		3	24 mo
Hydraulic Matrices Types:	$1,000-2,000/ac	65 - 99%	2,000 lbs/ac mulch + 10% tackifier		
Wood mulch + Granular or liquid binder				2	6-12 mo
Paper mulch + Granular or liquid binder				2	3-6 mo
Cellulose mulch + binder				2	3-6 mo
Bonded Fiber Matrices	$5,000–6,500/ac	90 – 99%	3,500 – 4,000 lbs/ac	3	6-12 mo
Erosion Control Blankets and Mats Types:					
Biodegradable					
Jute	$6,000–7,000/ac	65 – 70%	N/A	4	12-18 mo
Curled Wood Fiber	$8,000–10,500/ac	90 – 99%	N/A	4	12 mo
Straw	$8,000–10,500/ac	90 – 99%	N/A	4	12 mo
Wood Fiber	$8,000–10,500/ac	90 – 99%	N/A	4	6-12 mo
Coconut Fiber	$13,000–14,000/ac	90 – 99%	N/A	4	24-36 mo
Coconut Fiber Net	$30,000–33,000/ac	90 – 99%	N/A	4	24-36 mo

Straw Coconut	$10,000–12,000/ac	90 – 99%	N/A	4	18-24 mo
Non-Biodegradable					
Plastic Netting	$2,000–2,200/ac	< 50%	N/A	4	24 mo
Plastic Mesh	$3,000–3,500/ac	75 – 80%	N/A	4	24 mo
Synthetic Fiber w/Netting	$34,000–40,000/ac	90 – 99%	N/A	4	permanent
Bonded Synthetic Fibers	$45,000–55,000/ac	90 – 99%	N/A	5	permanent
Combination Synthetic and Biodegradable Fibers	$30,000–36,000/ac	85 – 99%	N/A	5	variable
Criteria Definition					
Unit Cost Installed:	Cost of materials and labor to effect installation on a per acre basis				
Relative Erosion Control:	Reduction in soil loss when mulch is compared to bare soil (control) under similar conditions of soil, slope length and steepness and rainfall simulation				
Ease of Installation:	Ratings range from 1 (relatively easy or few steps required for application/installation) to 5 (labor intensive or numerous steps required for application/installation)				
Longevity/Degradability:	Functional longevity in terms of erosion control effectiveness				
Source: Erosion Control Pilot Study Report, Caltrans, June 2000, and Soil Stabilization for Temporary Slopes, Caltrans 1999. Adapted and Updated January 2005					

- Conduct work when there is adequate moisture in the ground to support plant germination and growth, preferably before the wet season, or provide supplemental irrigation. (Note: In Gresham, compost tends to furnish its own moisture sufficient for seed germination.)
- Apply seed, fertilizer, and mulch in a two-step process, with seed and fertilizer applied in the first step, and the mulch applied over the seed in a second step (see Planting under EP-5 or EP-6).
- Use mulches with some form of tackifying agent to hold them on the soil.
- Re-apply as necessary due to weathering—be prepared to budget for two seasons of inspection and maintenance.

Bonded Fiber Matrices: Bonded Fiber Matrices (BFMs) are hydraulically-applied, erosion prevention systems composed of long strand mulch fibers joined together by high-strength adhesives, creating a continuous, three-dimensional blanket that adheres to the soil surface. The system is applied to the soil as a viscous mixture, and when it dries (depending on the product, BFMs require 12-24 hours to dry to become effective), creates a high-strength, porous and erosion-resistant mat.

BFMs are typically applied at rates from 1.5 to 2 tons/acre based on the manufacturer's recommendation.

Some characteristics of bonded fiber matrices are:

- They can be applied using standard hydraulic seeding equipment.
- All components—fiber and adhesives—are mixed together in one bag.
- The binder systems do not dissolve or disperse upon rewetting.
- The dried matrix is porous, allowing water to penetrate into the soil.
- They can be applied with or without seed and do not inhibit plant growth.

Construction Specifications/Installation:

- Mulch shall be used for temporary applications only; permanent erosion control measures shall also be applied.

- Prior to application, roughen embankment and fill areas by rolling with a crimping or punching type roller or by track walking. Track walking shall only be used where other methods are impractical.
- Avoid mulch over-spray onto the traffic areas, sidewalks, lined drainage channels, and existing vegetation.
- Divert concentrated flows around mulched areas (RC-1, RC-3, RC-4, and RC-5).

Wood Fiber Mulch

- Wood fiber mulch is a component of hydraulic applications. It shall be used in combination with seed and fertilizer. It is typically applied at the rate of 2,000-4,000 lb/acre with 0-5% by weight of a stabilizing emulsion or tackifier (e.g., guar, psyllium, acrylic copolymer) and applied as a slurry. This type of mulch is manufactured from wood or wood waste from lumber mills or from urban sources.
- Wood fiber mulch can be specified with or without a tackifier; previous work has shown that wood fiber mulches with tackifiers have better erosion control performances.
- Materials for wood fiber based hydraulic mulches and hydraulic matrices shall conform to Oregon DOT Standard Specifications.

Recycled Paper Mulch

- Recycled paper mulch contains fibers of shorter length than wood fiber mulches and is typically made from recycled newsprint, magazine, or other waste paper sources. It is a component of hydraulic applications and shall be used in combination with seed and fertilizer. It is typically applied at the rate of 1-2 tons/acre. It can be specified with or without a tackifier.

Green Material

- This type of mulch is produced by recycling vegetation trimmings such as grass, shredded shrubs and trees. Methods of application are generally by hand, although pneumatic methods are available. Mulch shall be composted to kill weed seeds.
- It may be used as a temporary ground cover with or without seeding.
- The green material shall be evenly distributed on site to a depth of not more than 2 inches.

Hydraulic Matrix

- Hydraulic matrix is a combination of wood fiber mulch and a tackifier applied as a slurry. It is typically applied at the rate of 2,000-4,000 lb/acre with 5-10% by weight of a stabilizing emulsion or tackifier (e.g., guar, psyllium, acrylic copolymer).
- Materials for wood fiber based hydraulic mulches and hydraulic matrices shall conform to Oregon DOT Standard Specifications.
- Hydraulic matrices require 24 hours to dry before rainfall occurs to be effective unless approved by the City inspector.

Bonded Fiber Matrix

- Bonded fiber matrix (BFM) is a hydraulically-applied system of fibers and adhesives that upon drying forms an erosion-resistant blanket that promotes vegetation, and prevents soil erosion. BFMs are typically applied at rates from 3,000 to 4,000 lb/acre based on the manufacturer's recommendation. The biodegradable BFM is composed of materials that are 100% biodegradable. The binder in the BFM shall also be biodegradable and shall not dissolve or disperse upon re-wetting. Biodegradable BFMs shall not be applied immediately before, during, or immediately after rainfall if the soil is saturated. Depending on the product, BFMs require 12-24 hours to dry to become effective.

- Bonded fiber matrices shall be applied from multiple directions to adequately cover the soil. Application from a single direction can result in shadowing, uneven coverage, and failure of the BFM.

Straw Mulch

- All materials shall conform to Oregon DOT Standard Specifications.
- Straw shall be derived from wheat, rice, or barley. The straw mulch contractor shall furnish evidence that clearance has been obtained from the County Agricultural Commissioner, as required by law, before straw obtained from outside the county is delivered to the site of the work. Straw that has been used for stable bedding shall not be used.
- Apply loose straw at a minimum rate of 4,000 lb/acre, or as indicated in the project EPSC Plan, either by machine or by hand distribution.
- The straw mulch must be evenly distributed on the soil surface.
- Avoid placing straw onto the traffic areas, sidewalks, lined drainage channels, walls, and existing vegetation.
- Anchor the mulch in place by using a tackifier (preferred) or by punching or crimping it into the soil by mechanical incorporation.
- If using a tackifier to anchor the straw mulch in lieu of incorporation, roughen embankment or fill areas by rolling with a crimping or punching-type roller or by track walking before placing the straw mulch. Track walking shall only be used where rolling is impractical.
- A tackifier acts to glue the straw fibers together and to the soil surface. The tackifier shall be selected based on longevity and ability to hold the fibers in place (see Oregon DOT Standard Specifications).
- A tackifier is typically applied at a rate of 125 lb/acre. In windy conditions, the rate is typically 178 lb/acre.
- Straw mulch with tackifier shall not be applied during or immediately before rainfall.
- Methods for holding the straw mulch in place depend upon the slope steepness, accessibility, soil conditions and longevity. If the selected method is mechanical incorporation of straw mulch into the soil, then it shall be applied as follows:
    - Applying and incorporating straw shall follow the requirements in Oregon DOT Standard Specifications.
    - On small areas, a spade or shovel may be used.
    - On slopes with soils, which are stable enough and of sufficient gradient to safely support construction equipment without contributing to compaction and instability problems, straw may be punched into the ground using a knife-blade roller or a straight bladed coulter, known commercially as a "crimper."
    - On small areas and/or steep slopes, straw may also be held in place using plastic netting or jute. The netting shall be held in place using 11 gage wire staples, geotextile pins, or wooden stakes. Refer to Erosion Control Blankets and Mats (EP-10).

Monitoring / Maintenance:

- Maintain a continuous, temporary mulched ground cover throughout the period of construction when the disturbed soils are not being reworked or in areas that are non-active.
- Inspect before expected rain events. Repair any damaged ground cover and re-mulch exposed areas.
- The key consideration in maintenance and inspection is that the mulch needs to last long enough to achieve erosion control objectives. Mulch is a temporary ground cover and not suitable for long-term erosion control.

- Reapplication of mulch and tackifier may be required to maintain effective soil stabilization over disturbed areas and slopes.
- After any rainfall event, slopes shall be inspected and maintained to reduce or prevent erosion.

Common Failures:

- Areas where healthy vegetation cover failed to establish.
- Drainage-related failures, such as concentrated runoff.

COMPOST BLANKETS – EP-9

Application: A compost blanket is a layer of compost designed to prevent erosion, especially rills and gullies that may form under more traditional methods of erosion control. In many cases, a compost blanket can be more effective at vegetation establishment, weed suppression, and erosion control than an erosion control blanket (ECB) because it comes in better contact with the underlying soil, reducing the chance of rill formation. Compost blankets can be applied by hand, conveyor system or compost spreader; however, the most cost-effective and efficient method is the use of a pneumatic delivery system, i.e. a compost blower truck.

A compost blanket is used on slopes to prevent erosion from rain impact and, in some cases, to increase infiltration rates. Compost blankets can increase infiltration rates and decrease sediment delivery by 99% compared to bare soil. Compost binds heavy metals and can break hydrocarbons down into carbon, salts and other harmless compounds. Run-off from compost treated sites has very low soluble salts, and all metals and nutrients are well within pollution leaching limits. Compost is organic, biodegradable, renewable, and can be left onsite—particularly important near streams

Design Guidelines: Testing has shown that compost blankets are effective on up to a 2H:1V slope. For steeper slopes, there are products designed to enhance adhesion of the compost to the slope, but the effectiveness of such products are unknown. Adding components such as a tackifier, or using compost blankets in conjunction with other techniques such as compost berms as slope interrupters can increase the allowable steepness of the slope to be treated. However, slopes of this steepness would likely require customized stabilization techniques recommended by an engineer.

Materials/Equipment: There are many types of compost, all with different properties. Compost can be derived from feedstocks, biosolids, leaf and yard trimmings, manure, wood, or mixed solid waste, and must be treated with heat to remove pathogens and destroy noxious weeds. The most important criteria for quality compost are the "cooking" temperature and the duration of composting.

All types of vegetation have different nutrient or moisture needs; therefore, a compost sample shall be inspected by a qualified individual and compost specifications modified as necessary. For compost blankets, compost shall have the specifications presented in Table EP-9.1 (after AASHTO).

Compost that is too dry is harder to apply, while that which is too wet is heavier and harder to transport. In Gresham, use compost with slightly drier moisture content because it will absorb water. The percentage of carbon based materials in finished compost shall range between 40-70%—compost with higher percentages of organic matter is preferred.

Compost must be weed and pesticide free, with manmade materials comprising less than 1%. Compost blankets can be applied in a variety of ways; however, the most efficient and cost-effective way is through the use of a pneumatic blower truck.

Construction Specifications/Installation:

- Prepare the slopes by removing loose rocks, roots, clods, stumps and debris over 2 inches in diameter.
- Track-walk slopes if feasible before application.
- For very steep slopes (2H:1V to 1V:1V), compost berms can be installed along the contour at intervals over the compost blanket in much a similar manner as fiber rolls and tackifier applied to improve effectiveness.
- Compost blankets shall be extended 3-6 feet over the top shoulder of the slope to prevent water from flowing underneath.

- Compost blankets shall not be applied in areas of concentrated flow, and can be used in conjunction with compost berms or socks.
- Blankets are applied in thicknesses of 1/2 inch to 4 inches, depending upon the intended purpose. As a general rule, the more precipitation, the thicker the required compost blanket. For maximum unvegetated erosion control, use thicker blankets. For unvegetated applications (without seed), the compost blanket shall range from 2 to 4 inches thick. For vegetated applications (with seed), the compost blanket shall range from 1.5 to 2 inches thick.

Monitoring / Maintenance: Inspect blankets after each rain event. Re-apply blanket material if needed. Blankets can be hydroseeded if vegetation fails to establish.

Common Failures:

- The success of compost blankets is dependent upon the blanket not being undermined by water; this can be accomplished by keying in the top of the blanket, or the use of a compost berm or sock at the top of the slope.
- Another frequent cause of failure is poor maintenance.

TABLE EP-9.1. COMPOST SPECIFICATIONS

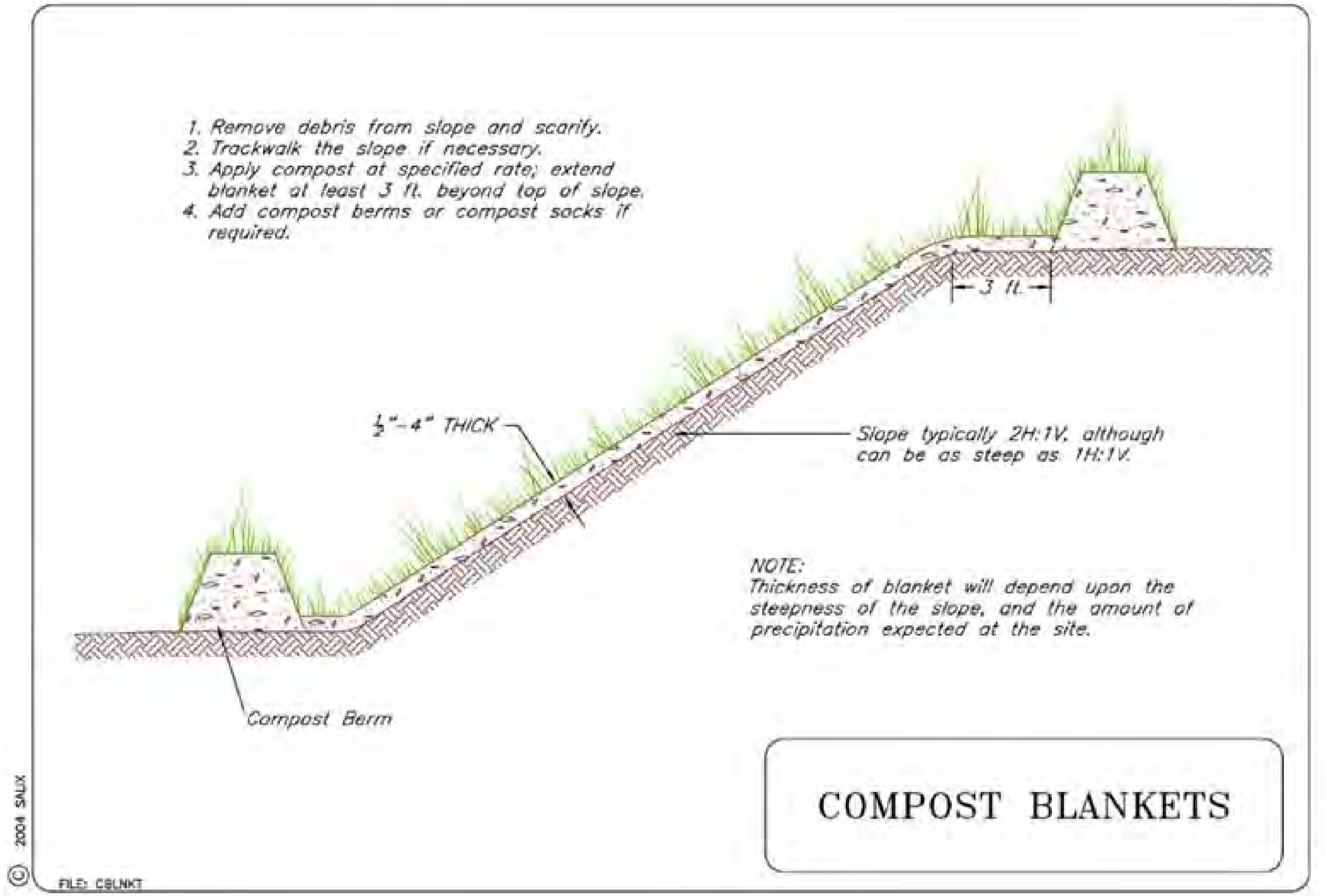
Parameters[1,4]	Reported as (Units of Measure)	Surface Mulch to be Vegetated	Surface Mulch to be left Unvegetated
pH[2]	pH units	5.0-8.5	N/A
Soluble Salt Concentration[2] (electrical conductivity)	dS/m	Maximum 5	Maximum 5
Moisture Content	%, wet weight basis	30-60	30-60
Organic Matter Content	%, wet weight basis	25-65	25-100
Particle Size	% passing a selected mesh size, dry weight basis	3", 100% passing 1", 90% to 100% passing ¾", 65%-100% passing ½", 0%-75% passing Max. particle length = 6	3", 100% passing 1", 90% to 100% passing ¾", 65%-100% passing ½", 0%-75% passing Max. particle length = 6
Stability[3] Carbon Dioxide Evolution Rate	Mg CO^2-C per g OM per day	<8	N/A
Physical Contaminants (man-made inerts)	%, dry weight basis	<1	<1

[1] Recommended test methodologies are provided in Test Methods for the Examination of Composting and Compost (TMECC, the US Composting Council).

[2] Each specific plant species requires a specific pH range. Each plant also has a salinity tolerance rating, and maximum tolerable quantities are known. When specifying the establishment of any plant or turf species, it is important to understand their pH and soluble salt requirements, and how they relate to the compost in use.

[3] Stability/Maturity rating is an area of compost science that is still evolving, and as such, other various test methods could be considered. Also, never base compost quality conclusions on the result of a single stability/maturity test.

[4] Landscape architects and project (field) engineers may modify the allowable compost specification ranges based on specific field conditions and plant requirements.


1. Remove debris from slope and scarify.
2. Trackwalk the slope if necessary.
3. Apply compost at specified rate; extend blanket at least 3 ft. beyond top of slope.
4. Add compost berms or compost socks if required.
½"–4" THICK
Slope typically 2H:1V, although can be as steep as 1H:1V.
3 ft.
NOTE:
Thickness of blanket will depend upon the steepness of the slope, and the amount of precipitation expected at the site.
Compost Berm
COMPOST BLANKETS
© 2004 SALIX
FILE: CBLNKT

EROSION CONTROL BLANKETS AND MATS – EP-10

Application: Erosion control blankets and mats (also known as rolled erosion control products—RECPs) are rolled, blanket-like materials used to provide erosion control by protecting the bare soil from rainfall impact, increasing infiltration, and promoting vegetation by protecting seeds from predators and moderating soil temperature. This class of products includes manufactured mulch materials that are produced in a roll configuration that is placed on the ground and held in place by stakes, metal staples, geotextile pins or other fastening systems. The mulch within the blanket can be held in place by netting, sewing, adhesives or a combination of these methods. Erosion control blankets and mats can be biodegradable or synthetic and can be temporary or permanent erosion control applications.

Design Guidelines: Always follow the manufacturer's recommendation on staple types, patterns and the number to use per square yard.

Materials/Equipment:

Erosion control blankets are grouped into three types: biodegradable, non-biodegradable, and a combination of synthetic and biodegradable.

Biodegradable Blankets and Mats

In order for blankets to be considered 100% biodegradable, the netting, sewing or adhesive system that holds the biodegradable mulch fibers together must also be biodegradable. Biodegradable blankets and mats are typically composed of jute fibers, curled wood fibers, straw, coconut fiber, or a combination of these materials.

- **Jute Mesh:** Jute is a natural fiber that is made into a yarn which is loosely woven into a biodegradable mesh. It is designed to be used in conjunction with vegetation and has longevity of approximately one year. The material is supplied in rolled strips, which shall be secured to the soil with U-shaped staples or stakes in accordance with manufacturers' recommendations. This mat is not to be used as a sole treatment for groundcover within the City.

- **Curled Wood Fiber:** Excelsior (curled wood fiber) blanket material shall consist of machine produced mats of curled wood excelsior with 80% of the fiber 6 inches or longer. The excelsior blanket shall be of consistent thickness. The wood fiber shall be evenly distributed over the entire area of the blanket. The top surface of the blanket shall be covered with a photodegradable extruded plastic mesh. The blanket shall be smolder resistant without the use of chemical additives and shall be non-toxic and non-injurious to plant and animal life. Excelsior blanket shall be furnished in rolled strips, a minimum of 4 feet wide, and shall have an average weight of 0.1 lb/ft^2, ±10%, at the time of manufacture. Excelsior blankets shall be secured in place with wire staples. Staples shall be made of 0.12-inch steel wire and shall be U-shaped with 8-inch legs and a 2-inch crown. Always follow the manufacturer's recommendation on staple types, patterns and the number to use per square yard or meter.

- **Straw:** Straw blankets shall be machine-produced mats of straw with a lightweight biodegradable netting top layer. The straw shall be attached to the netting with biodegradable thread or glue strips. The straw blanket shall be of consistent thickness. The straw shall be evenly distributed over the entire area of the blanket. Straw blanket shall be furnished in rolled strips a minimum of 6.5 feet wide, a minimum of 80 feet long and a minimum of 0.05 lbs/ft^2. Straw blankets shall be secured in place with wire staples. Staples shall be made of 0.12-inch steel wire and shall be U-shaped with 8-inch legs and a 2-inch crown.

- **Wood Fiber:** Wood fiber blankets are comprised of biodegradable fiber mulches with extruded plastic netting held together with adhesives. The material is designed to enhance revegetation. The material is furnished in rolled strips, which shall be secured to the ground with U-shaped staples or stakes in accordance with manufacturers' recommendations.

- **Coconut Fiber:** Coconut fiber blankets shall be machine-produced mats of 100% coconut fiber with biodegradable netting on the top and bottom. The coconut fiber shall be attached to the netting with biodegradable thread or glue strips. The coconut fiber blanket shall be of consistent thickness. The coconut fiber shall be evenly distributed over the entire area of the blanket. Coconut fiber blanket shall be furnished in rolled strips a minimum of 6.5 feet wide, a minimum of 80 feet long and a minimum of 0.05 lbs/ft^2. Coconut fiber blankets shall be secured in place with wire staples. Staples shall be made of 0.12-inch steel wire and shall be U-shaped with 8-inch legs and a 2-inch crown.

- **Coconut Fiber Mesh:** Coconut fiber mesh is a thin permeable membrane made from coconut or corn fiber that is spun into a yarn and woven into a biodegradable mat. It is designed to be used in conjunction with vegetation and typically has longevity of several years. The material is supplied in rolled strips, which shall be secured to the soil with U-shaped staples or stakes in accordance with manufacturers' recommendations.

- **Straw Coconut Fiber:** Straw coconut fiber blankets shall be machine-produced mats of 70% straw and 30% coconut fiber with a biodegradable netting top layer and a biodegradable bottom net. The straw and coconut fiber shall be attached to the netting with biodegradable thread or glue strips. The straw coconut fiber blanket shall be of consistent thickness. The straw and coconut fiber shall be evenly distributed over the entire area of the blanket. Straw coconut fiber blanket shall be furnished in rolled strips a minimum of 6.5 feet wide, a minimum of 80 feet long and a minimum of 0.05 lbs/ft^2. Straw coconut fiber blankets shall be secured in place with wire staples. Staples shall be made of 0.12-inch steel wire and shall be U-shaped with 8-inch legs and a 2-inch crown.

Non-Biodegradable Blankets and Mats

Non-biodegradable blankets and mats are typically composed of polypropylene, polyethylene, nylon or other synthetic fibers. In some cases, a combination of biodegradable and synthetic fibers is used to construct the blanket. Netting used to hold these fibers together is typically non-biodegradable.

- **Plastic Netting:** Plastic netting is a lightweight biaxially-oriented netting designed for securing loose mulches like straw or paper to soil surfaces to establish vegetation. The netting is photodegradable. The netting is supplied in rolled strips, which shall be secured with U-shaped staples or stakes in accordance with manufacturers' recommendations.

- **Plastic Mesh:** Plastic mesh is an open-weave geotextile that is comprised of an extruded synthetic fiber woven into a mesh with an opening size of less than 0.2 inch. It is used with revegetation or may be used to secure loose fiber such as straw to the ground. The material is supplied in rolled strips, which shall be secured to the soil with U-shaped staples or stakes in accordance with manufacturers' recommendations.

- **Synthetic Fiber with Netting:** Synthetic fiber with netting is a mat that is comprised of durable synthetic fibers treated to resist chemicals and ultraviolet light. The mat is a dense, three-dimensional mesh of synthetic (typically polyolefin) fibers stitched between two polypropylene nets. The mats are designed to be revegetated and provide a permanent composite system of soil, roots, and geomatrix. The material is furnished in rolled strips, which shall be secured with U-shaped staples or stakes in accordance with manufacturers' recommendations.

- **Bonded Synthetic Fiber**: This type of product consists of three-dimensional geomatrix nylon (or other synthetic) matting. Typically it has more than ninety percent open area, which facilitates root growth. Its tough root-reinforcing system anchors vegetation and protects against hydraulic lift and shear forces created by high volume discharges. It can be installed over prepared soil, followed by seeding into the mat. Once vegetated, it becomes an invisible composite system of soil, roots, and geomatrix. The material is furnished in rolled strips that shall be secured with U-shaped staples or stakes in accordance with manufacturers' recommendations.

Combination Synthetic and Biodegradable Blankets and Mats

Combination synthetic and biodegradable blankets and mats consist of biodegradable fibers, such as wood fiber or coconut fiber, with a heavy polypropylene net stitched to the top and a high-strength continuous-filament geomatrix or net stitched to the bottom. The material is designed to enhance revegetation. The material is furnished in rolled strips, which shall be secured with U-shaped staples or stakes in accordance with manufacturers' recommendations.

Construction Specifications/Installation:

Site Preparation

- Proper site preparation is essential to ensure complete contact of the protection matting with the soil.
- Grade and shape area of installation.
- Remove all rocks, clods, vegetative, and other obstructions so that the installed blankets, or mats will have direct contact with the soil. Prepare seedbed by loosening 2-3 inches of topsoil above final grade.
- Incorporate amendments, such as lime and fertilizer, into soil according to soil test and the seeding plan.

Seeding

- Seed area before blanket installation for erosion control and revegetation. Seeding after mat installation is often specified for turf reinforcement application. When seeding prior to blanket installation, all check slots and other areas disturbed during installation must be reseeded.
- Where soil filling is specified, seed the matting and the entire disturbed area after installation and prior to filling the mat with soil.

Anchoring

- Anchoring of blankets and mats is the most critical element of installation. Anchoring devices must be selected to be compatible with site soil conditions.
- Where soil conditions are suitable (i.e., topsoil without substantial rocks or cobbles), biodegradable stakes, staples, or pins are preferred. Although biodegradable anchoring devices are preferred they must be compatible with soil conditions to ensure proper blanket installation.
- U-shaped wire staples, metal geotextile stake pins, or triangular wooden stakes can be used to anchor mats to the ground surface. Wire staples shall be a minimum of 11 gage. Metal stake pins shall be 3/16 inches diameter steel with a 1½ inch steel washer at the head of the pin. Wire staples and metal stakes shall be driven flush to the soil surface. Two inches of wood staking shall remain above the soil surface. All anchors shall be 6-18 inches long and have sufficient ground penetration to resist pullout. Longer anchors may be required for loose soils. See Table EP-10.1 for staking specifications.

TABLE EP-10.1. RECOMMENDATIONS FOR STAKE SELECTION

Stake Length	Soil Conditions
6 inches	Typical soil conditions. 6-inch staples used in all but loose soil types.
8 inches	Loam, relatively loose sandy loam to sandy soils. 8-inch staples are typically used in high velocity channel applications.
> 12 inches	Excessively loose soils, slopes containing fine silt, sand, or soft mud. Deep and soft fills, loose sands, silts, loams or "quick" conditions. 12-inch staples and longer are used in shoreline applications in which wave action is a factor or in instances where soils remain saturated for long periods of time.

Installation on Slopes

- Dig initial anchor trench 12 inches deep and 6 inches wide across the channel at the lower end of the project area.
- Begin at the top of the slope and anchor the blanket in a 6 inch deep x 6 inch wide trench. Backfill trench and tamp earth firmly.
- Unroll blanket down slope in the direction of the water flow.
- The edges of adjacent parallel rolls must be overlapped 2-3 inches and be stapled every 3 feet.
- When blankets must be spliced, place blankets end over end (shingle style) with a minimum of 6 inches overlap. Staple through overlapped area, approximately 12 inches apart.
- Lay blankets loosely and maintain direct contact with the soil - do not stretch.
- Blankets shall be stapled sufficiently to anchor blanket and maintain contact with the soil in accordance with manufacturer's specifications. Guidelines for installation are as follows: Staples shall be placed down the center and staggered with the staples placed along the edges. Steep slopes, 1H:1V to 2H:1V, require 2 staples per square yard. Moderate slopes, 2H:1V to 3H:1V, require 1-2 staples per square yard (1 staple, 3 feet on center). Gentle slopes require 1 staple/yd^2. See Table EP-10.2 for matting specifications.

TABLE EP-10.2. MATTING SPECIFICATIONS

Matting Type	Slope/Channel Application	Netting Type
Straw	3H:1V or less	Type 1: Photodegradable polypropylene top/bottom Type 2: 100% biodegradable (use near sensitive habitat areas)
Straw/Coconut	2H:1V or less	Type 1: Photodegradable polypropylene top/bottom Type 2: 100% biodegradable (use near sensitive habitat areas)
Coconut	1H:1V or less Low-flow channels	Type 1: Photodegradable polypropylene top/bottom Type 2: 100% biodegradable (use near sensitive habitat areas)
Jute	3H:1V or less Short 2H:1V slopes	100% biodegradable (not to be used as a sole treatment for groundcover)
Excelsior	2H:1V or less, low-flow channel	Photodegradable extruded plastic mesh top/bottom
Coir fabric	1H:1V or less 8-10 fps channel	Type 1: 1-inch grid, 100% biodegradable (4-10 year life) Type 2: ½-inch grid, 100% biodegradable (4-10 year life) Type 3: ¼-inch grid, 100% biodegradable (4-10 year life)
TRM	High-flow (8-20 fps) channels	Three-dimensional synthetic polyolefin fibers mechanically bonded between two nets

Installation in Channels

- See channel preparation in Grass-Lined Channel (Turf Reinforcement Mats) (RC-5).

Soil Filling (if specified after turf reinforcement installation)

- After seeding, spread and lightly rake 1/2-3/4 inches of fine topsoil into the mat apertures to completely fill mat thickness. Use backside of rake or other flat implement.
- Spread topsoil using lightweight loader, backhoe, or other power equipment. Avoid sharp turns with equipment.

- Do not drive tracked or heavy equipment over mat. Avoid any traffic over matting if loose or wet soil conditions exist.
- Use shovels, rakes or brooms for fine grading and touch up.
- Smooth out soil filling, just exposing top netting of matrix.

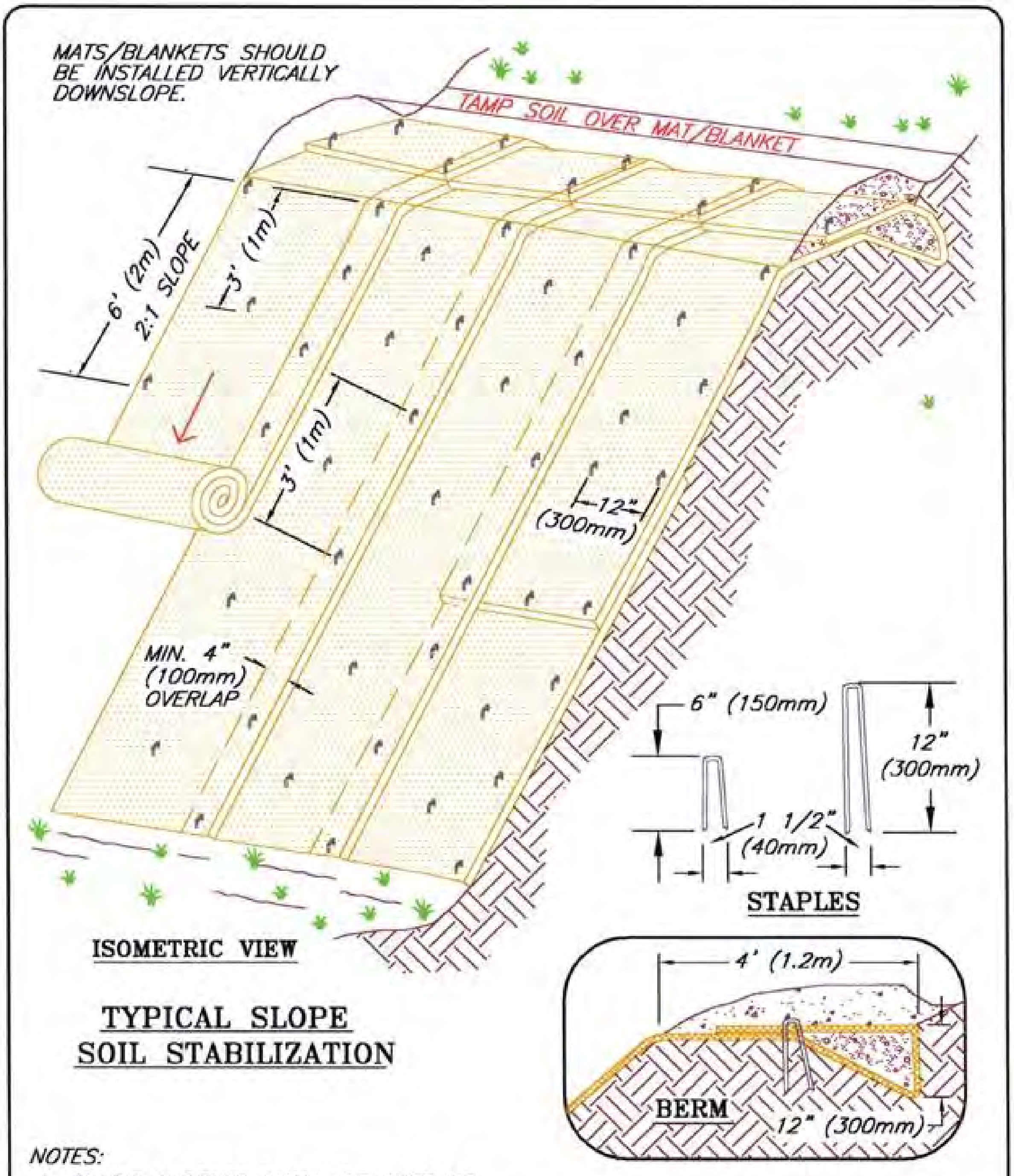
Alternate Installation Method for Slopes <4H:1V

- Place two rows of anchors on 6-inch centers at 25-30 foot intervals in lieu of excavated check slots.
- Shingle-lap spliced ends by a minimum of 1 foot with upstream mat on top to prevent uplifting by water or begin new rolls in a check slot. Anchor overlapped area by placing two rows of anchors, 1 foot apart on 1 foot intervals.
- Place edges of outside mats in previously excavated longitudinal slots, anchor using prescribed staple pattern, backfill and compact soil.
- Anchor, fill and compact upstream end of mat in a 12-inch x 6-inch terminal trench.
- Secure mat to ground surface using U-shaped wire staples geotextile pins or wooden stakes.
- Seed and fill turf reinforcement matting with soil, if specified.

Monitoring / Maintenance:

- All blanket and mats shall be inspected following installation and in accordance with approved plan and permit requirements.
- Inspect installation before, during, and after storm events to check for erosion and undermining. Any failure shall be repaired immediately.
- If washout or breakage occurs, re-install the material after repairing the damage to the slope or drainageway.

Common Failures: A frequent cause of failure is poor installation and maintenance.



TYPICAL SLOPE SOIL STABILIZATION

NOTES:

1. SLOPE SURFACE SHALL BE FREE OF ROCKS, CLODS, STICKS AND GRASS. MATS/ BLANKETS SHALL HAVE GOOD SOIL CONTACT.
2. APPLY PERMANENT SEEDING BEFORE PLACING BLANKETS.
3. LAY BLANKETS LOOSELY AND STAKE OR STAPLE TO MAINTAIN DIRECT CONTACT WITH THE SOIL. DO NOT STRETCH.

NOT TO SCALE

EROSION BLANKETS & TURF REINFORCEMENT MATS SLOPE INSTALLATION

FILE: BLNKTSLP

SOIL BINDERS – EP-11

Application: Soil binders (also known as hydraulic soil stabilizers) are materials that are applied to the soil surface for dust control and temporary erosion control. When used in combination with plant materials (hay/straw) and hydraulic mulches, hydraulic soil stabilizers glue the mulch fibers together and are effective in controlling water-generated erosion.

Design Guidelines:

- Site-specific soil types will dictate appropriate soil binders to be used.
- A soil binder must be environmentally benign (non-toxic to plant and animal life), easy to apply, easy to maintain, economical, and shall not stain paved or painted surfaces, and conform to the following:
    - Stabilizing emulsion shall be a concentrated liquid chemical that forms a plastic film upon drying and allows water and air to penetrate.
    - Stabilizing emulsion shall be nontoxic to plant or animal life and nonstaining to concrete or painted surfaces. In the cured state, the stabilizing emulsion shall not be re-emulsifiable.
    - Stabilizing emulsion shall be miscible with water at the time of mixing and application.
    - A certificate of compliance for stabilizing emulsion shall be furnished to the City, as required.
- Select a soil binder that is compatible with existing vegetation.
- Performance of soil binders depends on temperature, humidity, and traffic across treated areas.

Selecting a Soil Binder

Factors to consider when selecting a soil binder include the following:

- Suitability to situation - Consider where the soil binder will be applied; determine if it needs a high resistance to leaching or abrasion, and whether it needs to be compatible with any existing vegetation. Determine the length of time soil stabilization will be needed, and if the soil binder will be placed in an area where it will degrade rapidly. In general, slope steepness is not a discriminating factor for the listed soil binders
- Soil types and surface materials - Fines and moisture content are key properties of surface materials Consider a soil binder's ability to penetrate, likelihood of leaching, and ability to form a surface crust on the surface materials.
- Frequency of application - The frequency of application can be affected by subgrade conditions, surface type, climate, and maintenance schedule. Frequent applications could lead to high costs. Application frequency may be minimized if the soil binder has good penetration, low evaporation, and good longevity. Consider also that frequent application will require frequent equipment clean-up.
- Cure Time – Consider cure time and minimum drying time in binder selection. Refer to Table EP-11.1 and confirm cure time and minimum drying time with manufacture's recommendations.

Materials/Equipment: Hydraulic soil stabilizers can be used in basically three types of applications:

- As a standalone application of liquid that forms a crust on the soil surface by binding soil particles together.
- As a tackifying agent applied over straw mulch as an alternative to crimping.
- In combination with hydraulic mulches to create a hydraulic matrix.

In general, there are four common classes of hydraulic soil stabilizers (see Table EP-11.2 for comparisons):

- Plant-Material Based (Short Lived)—Guar, Psyllium, Starch, Chitosan.
- Plant-Material Based (Long Lived)—Pitch and Rosin Emulsion.

- Polymeric Emulsion Blends—Acrylic Copolymers and Polymers, Liquid Polymers of Methacrylates and Acrylates, Copolymers of Sodium Acrylates and Acrylamides, Poly-Acrylamide and Coplymer of Acrylamide, and Hydro-Collid Polymers.
- Cementitious-Based Binders—Gypsum.

TABLE EP-11.1. PROPERTIES OF SOIL BINDERS FOR EROSION CONTROL

Chemicals	Plant Material Based (Short Lived)	Plant Material Based (Long Lived)	Polymeric Emulsion Blends	Cementitious-Based Binders
Relative Cost	Low	Low	Low	Low
Resistance to Leaching	High	High	Low to Moderate	Moderate
Resistance to Abrasion	Moderate	Low	Moderate to High	Moderate to High
Longevity	Short to Medium	Medium	Medium to Long	Medium
Minimum Curing Time before Rain	9-18 hrs	19-24 hrs	0-24 hrs	4-8 hrs
Compatibility with Existing Vegetation	Good	Poor	Poor	Poor
Mode of Degradation	Biodegradable	Biodegradable	Photodegradable/ Chemically Degradable	Photodegradable/ Chemically Degradable
Labor Intensive	No	No	No	No
Specialized Application Equipment	Water Truck or Hydraulic Mulcher	Water Truck or Hydraulic Mulcher	Water Truck or Hydraulic Mulcher	Water Truck or Hydraulic Mulcher
Liquid/Powder	Powder	Liquid	Liquid/Powder	Powder
Surface Crusting	Yes, but dissolves on rewetting	Yes	Yes, but dissolves on rewetting	Yes
Clean-Up	Water	Water	Water	Water
Erosion Control Application Rate	Varies[1]	Varies[1]	Varies[1]	4,000-12,000lb/ac

[1] Dependant on product, soil type, and slope inclination

TABLE EP-11.2. COMPARATIVE SELECTION CRITERIA—SOIL BINDERS								
Soil Binder (with out mulch)	**Unit Cost Installed**	**Relative Erosion Control**	**Degradability/ Longevity**	**Water Quality Impact**	**Ease of Cleanup**	**Mode of Application**	**Effect on Runoff**	**Drying Time (hrs)**
Plant Material-Based (PBS) Guar, Psyllium, Starch, Chitosan	$700-900/ac	85-95%	3-6 mo	+	+	B	0/-	12-18
Plant Material-Based (PBL) Pitch or rosin-based	$1,200-1,500/ ac	60-65%	6-12 mo	-	V	B	+	19-24
Polymeric Emulsion Blends (PEB) Acrylic copolymers, copolymers and hydrocolloids Polyacrylamides (PAM)	$700-1,500/ac	30-95%	1-2 yrs	V	V	B	+ and/or – depending on chemistry	4-24 Depending on chemistry
Cementitious Binder-Based (CBB) Generally used with trace mulch	$800-1,200/ac	75-85%	1-2 yrs	+	V	H	+	4-8

Criteria Definition	
Unit Cost Installed:	Cost of materials and labor to effect installation on a per acre basis
Relative Erosion Control:	Reduction in soil loss when binder compared to bare soil (control) under similar conditions of soil, slope length and steepness and rainfall simulation
Degradability/Longevity:	Based on manufacturers' standard recommended application rate and information/data sheets
Water Quality Impact:	Low, Medium or High based on the results of testing at the SDSU Soil Erosion Research Laboratory for Caltrans (See SSTS 1999). For detailed information on chemical constituents, ask the manufacturer for MSDS sheets and evidence of water quality testing.
Ease of Cleanup:	Positive (+) indicates that cleanup of overspray onto sidewalks, walls, etc. is generally not an issue. Negative (-) indicates that cleanup can be problematic. Variable (V) indicates that the chemistry of the particular binder can make a difference. Check with the manufacturer.
Mode of Application:	Indicates whether or not specific application equipment is required. Hydromulcher (H) indicates the need to mix and keep material in suspension by internal agitation; Water truck (W) means that the material is specifically designed for use with a standard water tank truck; Both (B) means that the material can be used in either a hydromulcher or a water truck with a recirculation pump or other means of preliminary mixing of binder with water.
Effect on Runoff:	A positive sign (+) indicates runoff is increased; a negative sign (-) means runoff is reduced; the symbol (0) indicates no-effect.
Source: Erosion Control Pilot Study Report, Caltrans, June 2000, and Soil Stabilization for Temporary Slopes, Caltrans 1999. Adapted and Updated January 2005.	

Construction Specifications/Installation:

The soil binders in Table EP-11.1 will be generally appropriate as follows:

Plant-Material Based (Short Lived)

- **Guar:** Guar is a non-toxic, biodegradable, natural galactomannan-based hydrocolloid treated with dispersant agents for easy field mixing. It shall be diluted at the rate of 1-5 lbs per 100 gallons of water, depending on application machine capacity. Minimum application rates are as follows (follow manufacturers recommended application rates):

APPLICATION RATES FOR GUAR SOIL STABILIZER					
Slope (H:V)	**Flat**	**4:1**	**3:1**	**2:1**	**1:1**
lb/ac	40	45	50	60	70

- **Psyllium:** Psyllium is composed of the finely ground muciloid coating of plantago seeds that is applied as a dry powder or in a wet slurry to the surface of the soil. It dries to form a firm but re-wettable membrane that binds soil particles together but permits germination and growth of seed. Psyllium requires 12-18 hours drying time. Psyllium shall be applied at a rate of 80-200 lbs/acre, with enough water in solution to allow for a uniform slurry flow.
- **Starch:** Starch is non-ionic, cold-water soluble (pre-gelatinized) granular cornstarch. The material is mixed with water and applied at the rate of 150 lbs/acre, with an approximate drying time of 9-12 hours.

Plant-Material Based (Long Lived)

- Pitch and Rosin Emulsion: Generally, a non-ionic pitch and rosin emulsion has a minimum solids content of 48%. The rosin shall be a minimum of 26% of the total solids content. The soil stabilizer shall be non-corrosive, water-dilutable emulsion that upon application cures to a water-insoluble binding and cementing agent. For soil erosion control applications, the emulsion is diluted and shall be applied as follows:
    - For clayey soil: 5 parts water to 1 part emulsion.
    - For sandy soil: 10 parts water to 1 part emulsion.
- Application can be by water truck or hydraulic seeder with the emulsion/product mixture applied at the rate specified by the manufacturer. The approximate drying time is 19-24 hours.

Polymeric Emulsion Blends

- **Acrylic Copolymers and Polymers:** Polymeric soil stabilizers shall consist of a liquid or solid polymer or copolymer with an acrylic base that contains a minimum of 55% solids. The polymeric compound shall be handled and mixed in a manner that will not cause foaming or shall contain an anti-foaming agent. The polymeric emulsion shall not exceed its shelf life or expiration date; manufacturers shall provide the expiration date. Polymeric soil stabilizer shall be readily miscible in water, non-injurious to seed or animal life, non-flammable, shall provide surface soil stabilization for various soil types without totally inhibiting water infiltration, and shall not re-emulsify when cured. The applied compound shall air cure within a maximum of 36-48 hours. Liquid copolymer shall be diluted at a rate of 10 parts water to 1 part polymer and applied to soil at a rate of 1,175 gallons/acre.
- **Liquid Polymers of Methacrylates and Acrylates:** This material consists of a tackifier/sealer that is a liquid polymer of Methacrylates and Acrylates. It is an aqueous 100% acrylic emulsion blend of 40% solids by volume that is free from styrene, acetate, vinyl, ethoxylated surfactants or silicates. For soil stabilization applications, it is diluted with water in accordance with manufacturer's recommendations, and applied with a hydraulic seeder at the rate of 20 gallons/acre. The drying time is 12-18 hours after application.
- **Copolymers of Sodium Acrylates and Acrylamides:** These materials are non-toxic, dry powders that are copolymers of sodium acrylate and acrylamide. They are mixed with water and applied to the soil surface for erosion control at rates that are determined by slope gradient:

APPLICATION RATES FOR COPOLYMERS OF SODIUM ACRYLATES AND ACRYLAMIDES	
Slope Gradient (H:V)	**lb/ac**
Flat to 5:1	3-5
5:1 to 3:1	5-10
2:1 to 1:1	10-20

- **Poly-Acrylamide and Copolymer of Acrylamide:** Linear copolymer polyacrylamide is packaged as a dry-flowable solid. When used as a stand-alone stabilizer, it is diluted at a rate of 1 lb/100 gallons of water and applied at the rate of 5 lbs/acre.
- **Hydro-Colloid Polymers:** Hydro-Colloid Polymers are various combinations of dry-flowable poly-acrylamides, copolymers and hydro-colloid polymers that are mixed with water and applied to the soil surface at rates of 53-62 lbs/acre. The drying time is 0-4 hours.

Cementitious-Based Binders

- **Gypsum:** This is a formulated gypsum-based product that readily mixes with water and mulch to form a thin protective crust on the soil surface. It is composed of high purity gypsum that is ground, calcined and processed into calcium sulfate hemihydrate with a minimum purity of 86%. It is mixed in a hydraulic seeder and applied at rates 4,000-12,000 lb/acre. The drying time is 4-8 hours.

Soil Binder Applications

After selecting an appropriate soil binder, the untreated soil surface must be prepared before applying the soil binder. The untreated soil surface must contain sufficient moisture to assist the agent in achieving uniform distribution. In general, the following steps shall be followed:

- Follow manufacturer's recommendations for application rates, pre-wetting of application area, and cleaning of equipment after use.
- Prior to application, roughen embankment and fill areas by rolling with a crimping or punching type roller or by track walking. Track walking shall only be used where rolling is impractical.
- Consider the drying time for the selected soil binder and apply with sufficient time before anticipated rainfall. Soil binders shall not be applied during or immediately before rainfall.
- Avoid over-spray onto the traffic areas, sidewalks, lined drainage channels, sound walls, and existing vegetation.
- Soil binders shall not be applied to frozen soil, areas with standing water, under freezing or rainy conditions, or when the air temperature is below 40 ^{O}F during the curing period.
- More than one treatment is often necessary, although the second treatment may be diluted or have a lower application rate.
- Generally, soil binders require a minimum curing time of 24 hours before they are fully effective. Refer to manufacturer's instructions for specific cure times.
- For liquid agents:
  - Crown or slope ground to avoid ponding.
  - Uniformly pre-wet ground at 0.03-0.3 gallons/yd^2 or according to manufacturer's recommendations.
  - Apply solution under pressure. Overlap solution 6-12 inches.
  - Allow treated area to cure for the time recommended by the manufacturer; typically, at least 24 hours.
  - In low humidities, reactivate chemicals by re-wetting with water at 0.1-0.2 gallons/yd^2.

Monitoring / Maintenance:

- Reapplying the selected soil binder may be needed for proper maintenance. Inspections shall be conducted prior to and after rain events greater than ½ inch within 24-hours, and shall be performed no less than daily in high traffic areas and weekly in lower traffic areas.
- After any rainfall event, maintain all slopes to reduce or prevent erosion.
- Maintain a continuous, temporary stabilized area while disturbed soil areas are non-active. Repair any damaged stabilized area and re-apply soil binder to exposed areas.

STABILIZATION MATS – EP-12

Application: There are several techniques that involve the placement of relatively inexpensive and locally available material to stabilize the ground surface, especially for work around sensitive areas such as wetlands and streams. Stabilization mats reduce tracking from the construction site and create a stable pad for heavy equipment.

Materials/Equipment: Types of stabilization mats to consider include brush mats, corduroy mats, and board mats:

- **Brush Mats:** Brush mats are constructed of available slash (brush and trees), crushed in-place to form a mat. Their purpose is to support equipment so that there are minimal short term impacts in excessively wet conditions. This practice is limited to areas where brush is of sufficient thickness and density to stabilize the wetland bottom for vehicular/equipment use. In some cases, the brush mats may be left behind to naturally decay, although it may take 8-12 years for them to decay completely. According to a study that examined the effects of brush mat use in wetlands, leaving them in place did not restrict water movement or alter water regimes, and revegetation occurred quickly. The use of brush mats can reduce the need for slash management.
- **Corduroy Mats:** Corduroy mats are constructed of small logs, brush, or mill slabs placed one after the other, perpendicular to the equipment driving path. These types of mats can spread the load over the entire area of the log or slab and are effective in increasing the load bearing capacity of an area. Flotation increases by using longer pieces of material, particularly small logs or mill slabs. These mats may be practical where logs are readily available. Multiple layers of corduroy may be required in some areas. The use of corduroy mats can reduce the need for slash management.
- **Board Mats:** Board mats consist of "pallet like" units placed one after the other to form a crude yet rapidly placed stabilized surface. Board mats can be placed, used, and easily removed for temporary stabilization for short term equipment use.

Construction Specifications/Installation:

- Installation varies, depending on construction methods and site conditions.
- Comply with applicable permits when using in wetlands or waters.

Monitoring/Maintenance:

- Corduroy mats, and board mats shall be removed upon completion of work activity. Removal activities shall be timed to minimize soil disturbance.
- Brush mats may be left to degrade in place if permitted by the regulatory agency.
- Evidence of increased sedimentation, flow disruption, or other adverse effects of using mats shall be periodically inspected for, including following significant rain events. Repairs or changes shall be made as needed.
- Equipment/vehicles using mats shall be checked for gas leaks and oil leaks.

Common Failures: A frequent cause of failure is poor maintenance.

WIND EROSION / DUST CONTROL – EP-13

Application: Wind erosion control consists of dust control applications to protect soil from wind erosion or prevent dust generation from construction activities and equipment due to dry soil conditions. Wind erosion and dust control methods consist of applying water over susceptible areas or applying other dust mitigation as approved by the City.

Design Guidelines: Daily dust control shall be provided as needed to stabilize soil from wind erosion and to reduce dust generated by construction activities. Screen water intakes at streams to protect fish and obtain appropriate water withdrawal permit. Special attention shall be paid to stockpiled materials. Covering of small stockpiles or areas is an alternative to applying water or other dust mitigation.

Materials/Equipment: Non-potable water conveyed in tanks, trucks, drainpipes, or other conveyances. Plastic or geotextile sheeting.

Construction Specifications/Installation:

Dust control shall be provided daily or more often (as deemed necessary based on wind conditions, time of year, and physical conditions of the site) by application of water alone or with addition of magnesium chloride or calcium chloride in accordance with manufacturer's specifications.

Acrylic co-polymers or other biodegradable products (soil stabilizers/tackifiers) may be used for daily dust control if approved by the City.

Water applied for dust control shall be applied evenly and without over watering, which generates runoff and may result in erosion by water.

Oil or other petroleum-based products shall not be used for dust control.

Dust control must be implemented in accordance with state air quality requirements.

Monitoring/Maintenance:

Check areas protected to ensure appropriate coverage.

Reapply water or maintain covers, as necessary to be effective.

Common Failures:

A frequent cause of failure is over watering or poor maintenance.

LIVE STAKING – EP-14

Application: Live staking involves the insertion of live, vegetative cuttings, usually willows, into the ground in a manner that allows the cutting (stake) to take root and grow. Live stakes can create a root mat that stabilizes the soil by reinforcing and binding soil particles together. The BMP is one of several biotechnical erosion control (also known as soil bioengineering) techniques to arrest and prevent slope failures and erosion. Live stake establishment can improve aesthetics and provide wildlife habitat. As a temporary measure, live staking performs an important function of stabilizing and modifying the soil. The technique uses cuttings that are relatively short and small in diameter. Pole Planting (EP-15) is a related technique; however, the poles are much longer and thicker.

Live stakes are appropriate for repairing small earth slips and slumps. The stakes can help buttress the soil and arching. Gullies and bare gully banks can benefit from live staking. Live stakes can be used to anchor and enhance the effectiveness of wattles, fascines, fiber rolls, turf reinforcement mats and other erosion control materials. Live stakes do not initially provide erosion control. They work best if used in conjunction with other erosion prevention techniques during establishment period.

Design Guidelines: Live stakes are planted with the terminal buds or leaf nodes pointing up and the basal ends down into the soil. The buried portion of the cuttings develop roots, while the exposed portion produces branches and leaves. Depending on the species, the cuttings can grow into shrubs and/or trees. Because of its ability to root easily, the preferred plant species for live staking is willow (*Salix* spp.), but cottonwood (*Populus* spp.), dogwood (*Cornus* spp.), elderberry (*Sambucus* spp), and others have been used successfully.

Live stakes are useful for the following situations:

1. Live staking is useful as a revegetation technique and for establishing riparian plants in high flow or droughty situations.

2. Live staking can be used in irrigated or non-irrigated conditions with the latter being more prevalent. Irrigation can greatly increase vegetative success. Most often live staking is installed during the dormant season or when climactic or soil moisture conditions are favorable for establishment in non-irrigated conditions.

3. Live stakes provide an environmentally-sensitive anchoring technique for geotextiles and erosion control materials. The anchoring can be temporary or permanent depending on whether the stakes "take root."

4. Adding immediate failure resistance to the soil mass. While providing geotechnical benefits by "buttressing and arching," deep-seated failure planes underneath the bottom end of the cuttings will not usually be affected by live staking. These plants can remove excess soil moisture via evapotranspiration during the growing cycle, however these benefits will not be realized during dormancy.

Materials/Equipment: Live stakes are pieces of freshly cut woody plant stems planted, inserted, or driven in the ground or placed into erosion control or streambank stabilization structures. The branches vary from about 18-36 inches long, and typically ¾-3 inches in diameter. For Pole Planting (EP-15), the poles are much longer (3-15 feet long) and can be installed and arrayed differently.

Live stakes are typically made of woody riparian plant stems, although fleshy plant stems can have some success as well. Willow, cottonwood, and dogwood are the most used woody plants; however, willow cuttings make the best material for live stakes. Willow species are highly dependent on locale; the best species for a given site are those found growing near the site. Stakes are typically harvested and planted when the willows, or other chosen species, are dormant, although the cuttings can do well other times of year when soil moisture is available.

When harvesting cuttings:

- Select healthy, live wood that is reasonably straight, and at least 2 years old.
- Make clean, angular cuts without splitting ends.
- Trim branches from cutting as closely as possible.
- Cuttings shall generally be ¾ inch in diameter and a minimum 18 inches long, or larger depending on the species.
- The butt end of the cutting shall be pointed or angled and the top end shall be cut square to help identify the top and bottom when planting.
- The top, square end can be painted and sealed by dipping the top 1-2 inches into a 50-50 mix of light colored latex paint and water. Sealing the top of stake will reduce desiccation, ensure the stakes are planted with the top up, and make the stakes more visible for subsequent planting evaluations.
- Stakes must not be allowed to dry out. All cuttings shall be soaked in water for 5-7 days (a minimum of 24 hours) and planted the same day they are removed from the water.

Construction Specifications/Installation:

- Use an iron stake or bar to make a pilot hole in firm soil.
- Plant the basal ends into the ground, with the leaf bud scars or emerging buds always oriented up. Be careful not to damage the buds, strip the bark, or split the stake during installation.
- The stakes shall not be planted in rows or at regular intervals, but at random in the most suitable places at a rate of 2-5 cuttings/10 ft^2. However, if trying to control a group of people planting several thousand stakes, it may be found that it is easier to specify an average set interval.
- Set the stake as deep as possible into the soil, with 80% of its length into the soil. Deep planting will increase the chances of survival. The stake shall never protrude more than 20% of its length above the ground level to prevent it from drying. The excess stake or any damage or split ends can be cut off after installation. At least 2 buds and/or bud scars shall remain above the ground after planting.
- Add soil to the planting hole if necessary to ensure soil contact with the stem. It is important to tamp the soil around the cutting to ensure good soil-stem contact. The best installations, especially on dry sites, will include "watering in" and slightly compacting the backfill or hole. "Watering in," much like transplanting a container plant, can successfully be accomplished by pouring one to two gallons of water into the soil around the stake and planting hole, then slightly tamping or otherwise jarring the soil. This procedure will ensure complete soil to stem contact.

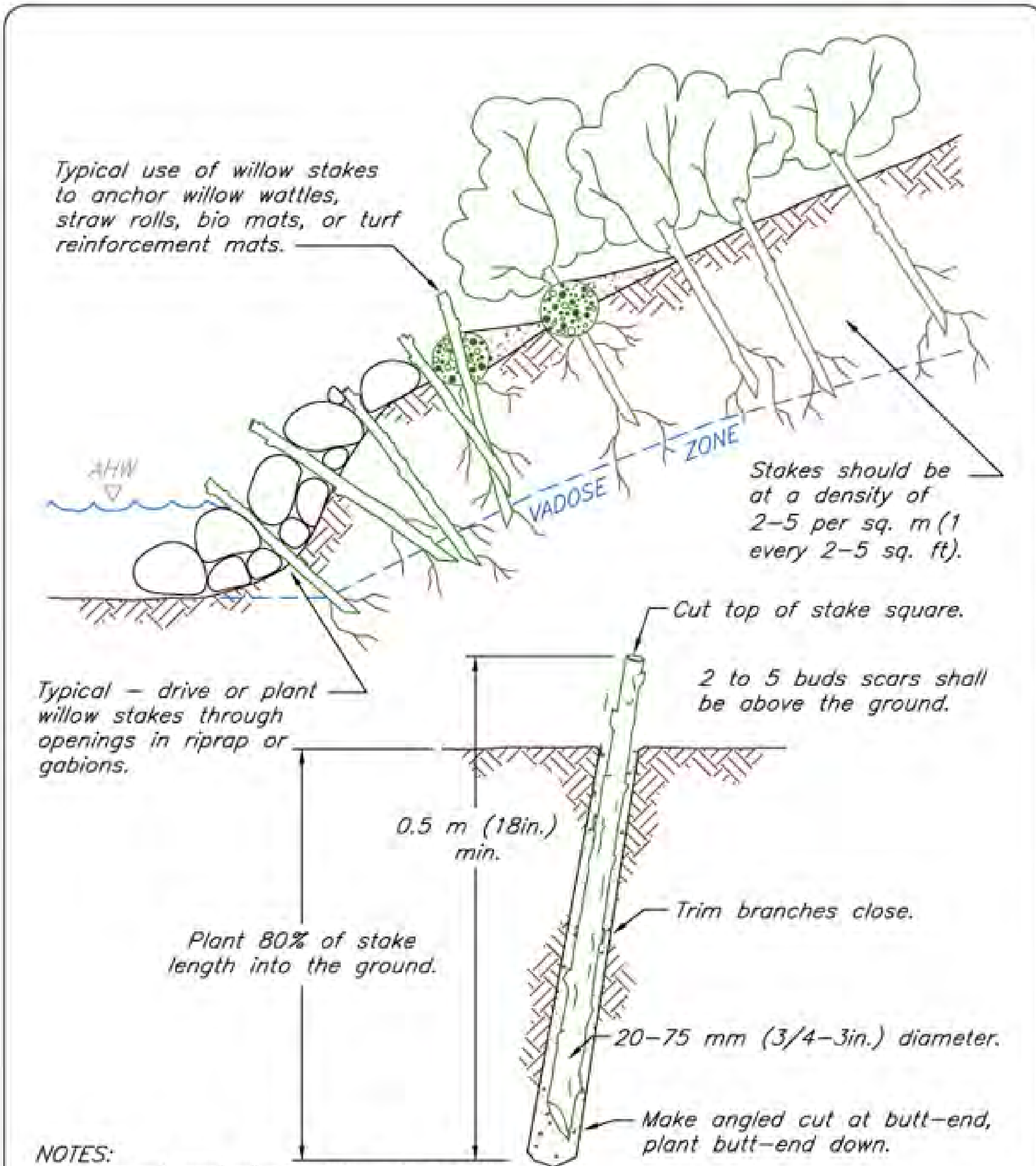
Monitoring/Maintenance:

Stakes shall be inspected every few weeks until well established, and irrigation, browse control (from livestock, deer, beavers, etc.), pruning, weed control, and fertilization shall be implemented as needed.

Common Failures:

Live staking can fail if vegetation is not handled properly prior to installation, is installed incorrectly (less than 80% of the cutting in the ground, bud scars facing down, poor soil contact, etc.) or not irrigated or "watered in" when installed in arid areas.

Another frequent cause of failure is poor maintenance.



NOTES:
1. Harvest and plant stakes during the dormant season.
2. Use healthy, straight and live wood at least 1 year old.
3. Make clean cuts and do not damage stakes or split ends during installation; use an iron bar and pilot hole in firm soils.
4. Soak cuttings for at least 24 hours prior to installation. Soak for 5–7 days for best results.
5. Tamp the soil around the stake.

LIVE STAKING AND JOINT PLANTING

FILE: LVSTK

Pole Planting – EP-15

Application: Pole plantings are one of several biotechnical erosion control (also known as soil bioengineering) techniques to arrest and prevent slope failures and erosion along streambanks; also used to enhance wildlife habitat and be aesthetically pleasing. The technique uses large diameter cuttings that are relatively long. The cuttings are intended to sprout and take root, stabilizing the streambank with a dense matrix of roots. Pole plantings are planted deep so they usually require heavy equipment assisted construction techniques. Live Staking (EP-14) is a related technique; however, the stakes are much shorter and can be installed manually.

Design Guidelines: Pole planting is suitable for floodplains, streambanks, and other riparian zones. Pole plantings are very useful for highly erodible areas and sites with fluctuating water tables. Pole planting is a useful "stand alone" revegetation technique for replacing and/or reestablishing riparian vegetation and cover. Pole planting is also particularly suitable for conjunctive uses with other streambank stabilization techniques such as vegetated riprap, vegetated gabions, rootwad revetments with vegetated riprap, vegetated deflectors, and longitudinal peaked stone toe protection.

Pole planting areas may need to be accessible to heavy equipment, as the poles shall be planted into deep holes. The location of the water table (saturated zone) and vadose zone (moist soil zone including the capillary fringe, located above the saturated zone) shall be approximately identified so the pole plantings can access sufficient moisture. Pole plantings are usually planted with a power auger or punch bar (Stinger).

Materials/Equipment: The cuttings usually are taken from willow (*Salix* spp.) or cottonwood (*Populus* spp.). Pole plantings use large diameter cuttings that are relatively long, straight, poorly branched stems, usually 5-10 feet in length. (For Live Staking (EP-14), the stakes are 18-36 inches long and can be installed and arrayed differently.)

A pond or storage area for soaking the cuttings will be necessary. Pole planting techniques may require the use of a power auger, stinger, or other method to excavate deep holes. The stinger is a large, pointed metal punch bar that is 4–6 inches in diameter, and mounted on a backhoe or hydraulic excavator.

Construction Specifications/Installation:

- Collect and harvest cuttings (ideally during the dormant season) and then soak the poles for 5-7 days.

- Plant poles into an augured, punched, or excavated hole. The holes shall extend to approximately 1 foot above the water table and through the vadose zone. This depth can be difficult to determine in areas with reservoirs and streams with widely fluctuating seasonal water levels. In this case, ensure that the ends of the poles reach the low waterline at the time of planting if possible.

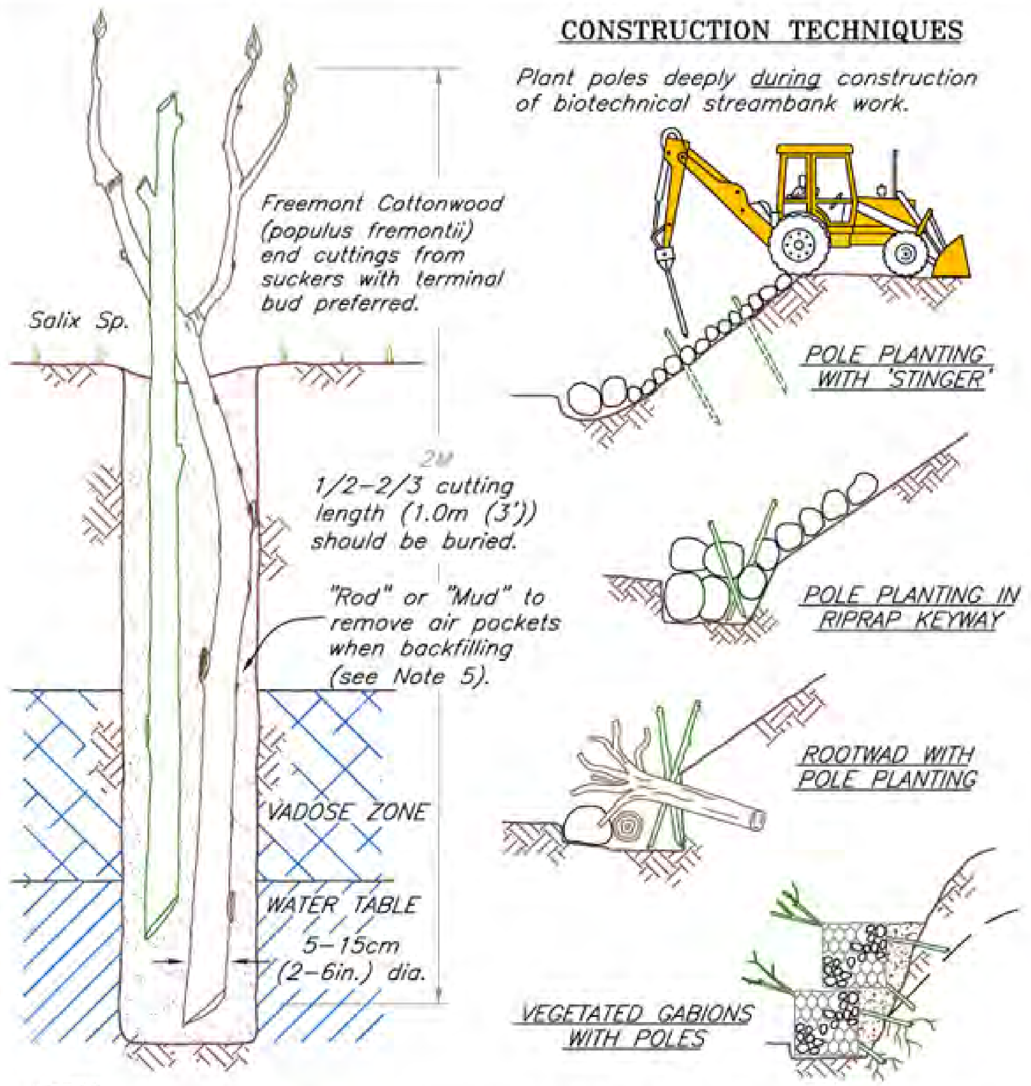
- Pole plantings shall ideally be installed during the construction of structures. For instance, plant the poles with the placement of riprap, especially into any trenches excavated for keyways or scour trenches. Another example is to plant the poles during riprap placement such that the poles extend through the riprap and backfill and into contact with the "native" bank.

- The backfill can be placed over and around the poles rather than having to "punch" holes through the riprap. Another method is to plant the poles during gabion construction.

- The pole plantings, especially the basal ends, must have good contact with the soil. "Mud" the hole (fill the hole with water and then add soil to make a mud slurry) to remove air pockets.

Monitoring / Maintenance: Poles shall be inspected every few weeks until well established, and irrigation, browse control (from livestock, deer, beavers, etc), pruning, weed control, and fertilization shall be implemented as needed.

Common Failures: A frequent cause of failure is poor maintenance.



NOTES:

1. Pole cuttings of willow or cottonwood are longer and have a larger diameter than branch cuttings or live stakes.
2. Larger diameter cuttings have a greater supply of stored energy (stored photosynthesis) than smaller diameter cuttings.
3. Pole cuttings are better suited for highly erodible areas and sites with fluctuating water levels.
4. The pole cuttings should extend through the vadose zone and into the permanent water table. At least 1/2 to 2/3 of the pole should be below the ground, at least 1.0 m (3 ft.), and long enough to emerge above adjacent vegetation.
5. "Muddying" – filling the hole with water and then soil to make a mud slurry can remove air pockets.

WILLOW POSTS & POLES

FILE: WPP

Live Fascines and Brush Wattles – EP-16

Application: Live fascines and brush wattles are bundles of live branch cuttings placed in long rows in shallow trenches across the slope on contour or at an angle. They are used for biotechnical stabilization of slopes and streambanks to arrest and prevent slope failures and erosion; also used to enhance wildlife habitat and be aesthetically pleasing.

▪ Fascines consist of bundles of straight, long, and slender branches of shrubs and trees capable of propagation, usually willows, which are packed together in rolls that are secured with twine or rope. Fascines are prepared and installed differently from wattles in that they are assembled with the branches and bud ends oriented in the same direction.

▪ Brush wattles consist of bundles of straight, long, and slender branches of shrubs and trees capable of propagation, usually willows, which are packed together in rolls that are secured with twine or rope. Wattles are prepared and installed differently from fascines in that they are assembled with the branches and bud ends oriented in alternating directions.

Design Guidelines: The technique is applicable where immediate erosion protection is necessary. This technique works best where flows are sufficient to keep the base of the bundle wet during most of the growing season, but do not exceed the flood tolerance of the fascine.

▪ Fascines are appropriate for use on slopes where the woody branch bundles shall be placed on a gradient for intercepting and transporting surface and shallow subsurface drainage. Fascines are preferable over brush wattles in areas with high rainfall, deep snow pack or where the collection of excess water on the slope may not be desirable.

Fascine spacing and configuration vary depending upon slope, exposure, and purpose:

- To treat overbank runoff on upper and mid bank areas, rows are installed on the contour.
- To divert runoff in upper and mid bank areas, rows are installed on a gradient.
- To trap sediment, rows are installed along the uphill side of v-ditch or other drainage structures.
- For flood flow protection, rows are installed perpendicular to flow in midbank areas.
- To treat wave erosion, rows are installed parallel to waves.
- On outer bends, and moist, seeping banks, fascines shall be installed at an angle of 45^{O}-60^{O} from horizontal, with the bud ends at the top, pointing upstream. On drier banks, and inner bends, fascines shall be installed on contour.
- Wattles are appropriate for use on long slopes, road cuts, gullies, slumped areas, eroded slopes, or eroding streambanks. Wattling may be used to stabilize entire cut or fill slopes or localized gully areas of slopes. Wattles may be used to repair small earth slips and slumps or to protect slopes from shallow slides 1–2 feet in depth. Wattles may be installed on newly built slopes or as remedial action on existing slopes. Wattling facilitates the natural invasion and establishment of plants from the surrounding plant community. Also see Fiber Rolls or Wattles (SC-7).

- Fascines and Brush Wattles are preferable over fiber rolls for slope interruption where it is feasible and desirable to establish shrubs on the slope using biotechnical erosion control techniques. Fascine drains can be used on wet slopes where there is evidence of subsurface seepage that is exacerbating erosion control problems. Also see Fascines with Subdrain (EP-18).

The condition of adjacent sites, including identifying successful plant species, growth form, and soil types, shall be assessed and compared to conditions on the construction site prior choosing fascine and wattle plant species.

Materials/Equipment: Fascines are made of brushy cuttings (stems that have leaves and twigs) of tree and shrub species capable of vegetative propagation, typically willow species. Plant material harvest and installation must be performed during its dormant season, late fall through early spring, or at other times of year if water is available. The cuttings shall be long, a minimum of 3 feet, straight brushy branches up to 1½ inch in diameter. For optimum success, the fascines shall be soaked for 24 hours or installed on the same day they are harvested and prepared.

Construction Specifications/Installation:

- Cuttings shall be tied together to form bundles, tapered at each end, 6-30 feet in length, depending on site conditions or limitations in handling. The completed bundles shall be 6-12 inches in diameter, with the growing tips and butt ends oriented in alternating directions (for fascines, ends oriented in the same direction).

- Stagger the cuttings in the bundles so that the tips are evenly distributed throughout the length of the bundle.

- Compress and tightly tie the bundle every 1 foot with rope or twine of sufficient strength and durability. Hemp, jute, cotton or other biodegradable rope may be used.

- Installation progresses from the bottom to the top of the slope.

- Install bundles into trenches dug into the slope on contour.

- Spacing of contour trenches (fascines) is determined by soil type, potential for erosion and slope steepness. See Table EP-16.1 below for general spacing guidelines.

TABLE EP-16.1. GENERAL INSTALLATION GUIDELINES	
Slope (H:V)	**Slope Length Between Fascines (ft)**
1:1 to 1.5:1	3-4
1.5:1 to 2:1	4-5
2:1 to 2.5:1	5-6
2.5:1 to 4:1	6-8
3.5:1 to 4:1	8-12
4.5:1 to 5:1	10-20

- The trench shall be shallow, about ½ the diameter of the fascine. The trench width will vary from 12-18 inches depending on the slope angle, but shall be at least 1 inch wider than the bundle.

  - In non-cohesive soils, the trench shall be lined with a coir erosion control blanket or netting prior to installation of the fascine.

- Fascines shall be staked firmly in place with one row of construction stakes on the downhill side of the bundle, not more than 3 feet apart. A second row of stakes shall be placed through the fascines, near the ties, at not more than 5 feet apart.

- Overlap the tapered ends of adjacent bundles at least 18 inches so the overall thickness of the fascine is uniform.

- Two stakes shall be used at each bundle overlap, such that a stake may be driven between the last two ties of each bundle. Live stakes, if specified, are generally installed on the downslope side of the bundle.

- Drive the live stakes below and against the bundle between the previously installed construction stakes.

- Repeat the proceeding steps to the top of the slope, placing moist soil along the sides of the live bundles.

- When finished, all live stakes shall be trimmed, such that a maximum of 3 inches of stake protrudes above the bundle.

- Fascines shall be keyed into the bank at least 3 feet on both upstream and downstream ends.

- Proper backfilling is essential to the successful rooting of the fascine.

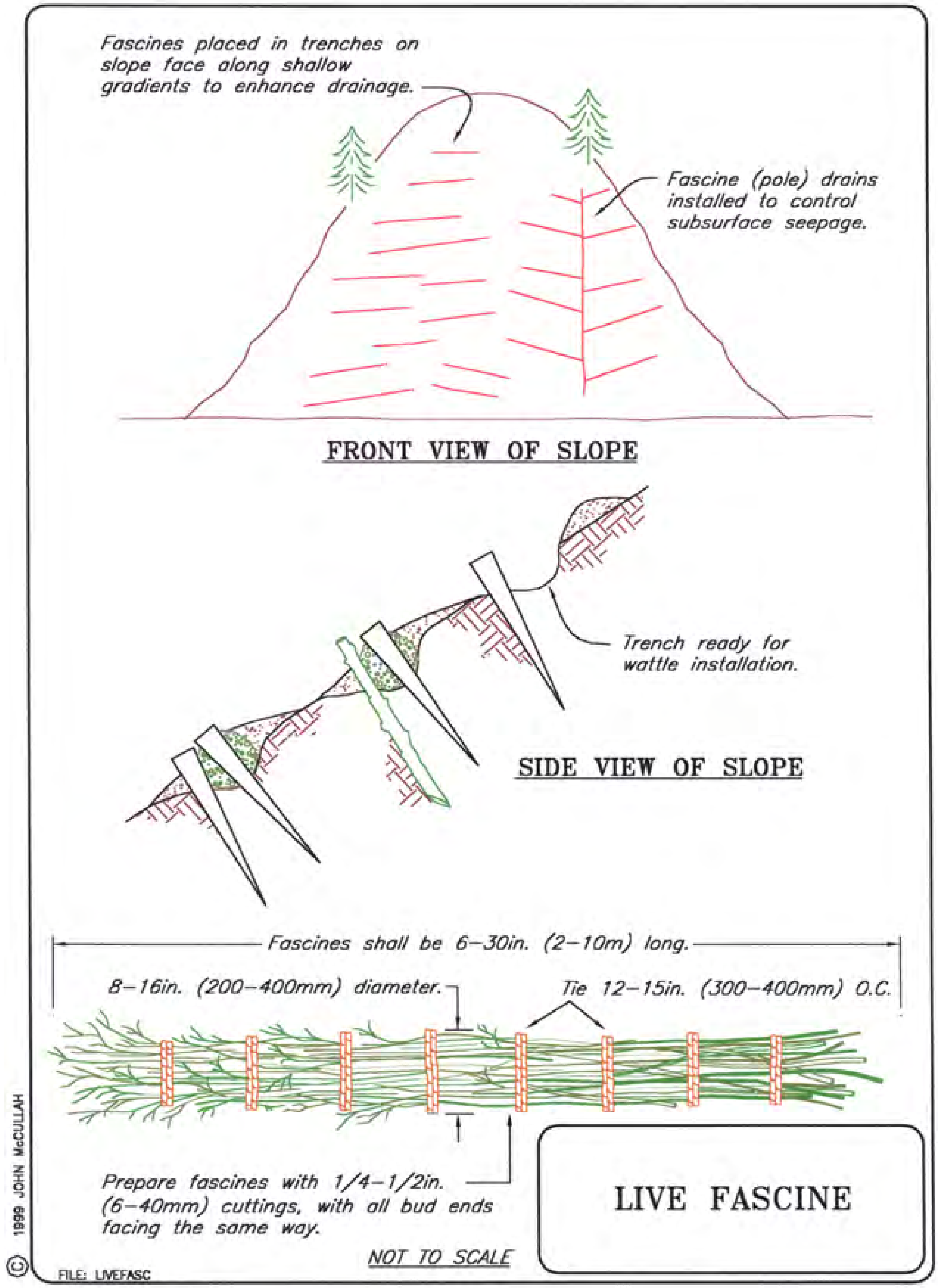
- Backfill bundles with soil from the slope or trench above. The backfill shall be worked into the fascine interstices and compacted behind and below the bundle by walking on and working from its terrace.

- Seed and mulch the slope. Shallow slopes, generally 3H:1V or flatter may be seeded and mulched by hand. Steeper slopes can have seed applied hydraulically and the mulch shall be anchored with tackifier or other approved methods.

Monitoring / Maintenance: Inspections shall occur after each of the first few floods, and/or twice the first year, and at least once each year thereafter.

Common Failures: Toe erosion and/or flanking can cause loss of the structure, if not combined with a toe protection in areas where shear stresses and velocities exceed limits for the soils underlying the structure. Flanking can be caused by insufficient keying-in of the structure.

Another frequent cause of failure is poor maintenance.


Fascines placed in trenches on slope face along shallow gradients to enhance drainage.
Fascine (pole) drains installed to control subsurface seepage.
FRONT VIEW OF SLOPE
Trench ready for wattle installation.
SIDE VIEW OF SLOPE
Fascines shall be 6–30in. (2–10m) long.
8–16in. (200–400mm) diameter.
Tie 12–15in. (300–400mm) O.C.
Prepare fascines with 1/4–1/2in. (6–40mm) cuttings, with all bud ends facing the same way.
NOT TO SCALE
LIVE FASCINE
© 1999 JOHN McCULLAH
FILE: LIVEFASC

Brush Box – EP-17

Application: Brush boxes are toe wall or breast wall type retaining structures constructed with branch cuttings, wooden construction stakes, and wire. The BMP is one of several biotechnical erosion control (also known as soil bioengineering) techniques to arrest and prevent slope failures and erosion; also used to enhance wildlife habitat and be aesthetically pleasing.

Design Guidelines: Brush boxes are best if constructed on firm ground at the toe of a small slump or along the toe of an oversteepened stream bank. Brush boxes require minimal excavation and require fill behind them. Brush boxes are larger and stronger than wattles and are therefore more suitable for buttressing the base of a slope.

Materials/Equipment: The ideal plant materials for brush boxes are those that: (1) root easily; (2) are long, straight and flexible; (3) are adapted to the site conditions; and (4) are plentiful near the job site.

Willow (*Salix* spp.) makes ideal cutting material. Some species of dogwood (*Cornus* spp.) and cottonwood (*Populus* spp.) also have very good rooting ability.

The cuttings shall be very long, 6-12 feet at a minimum, with straight branches up to 1½ inches in diameter. Trimmings of young suckers and some leafy branches may be included in the bundles to aid filtration. The number of stems varies with the size and kind of plant material. If willow or other rootable species are in short supply, non-rooting woody material may be used to partially fill the box (up to 50%).

Brush boxes require sturdy construction stakes, cut on a diagonal from vertical grained wood capable of being driven into the ground. Cut stakes at least 3 feet long. Wire, usually 9 gage or heavier, is required to bind the tops of the stakes together.

Construction Specifications/Installation:

- Work shall start at the bottom of the slope. Perform any slope repairs, such as runoff diversions (RC-3 and RC-4), prior to brush box installation.

- Dig a trench 12-18 inches wide and approximately 12 inches deep along the toe of the slump or stream bank.

- Drive construction stakes, 36-48 inches long, into the soil adjacent to the trench wall across from each other, one on the downhill side of the trench and one on the uphill side of the trench. Repeat the procedure by driving pairs of stakes every 2 feet along the length of the trench. Cut small notches into the stakes, approximately 3 inches from the top.

- Place the cuttings immediately after trenching to reduce desiccation of the soil. Cuttings shall be placed together between the stakes with the growing tips and butt ends oriented in alternating directions. Stagger the cuttings in the box so that the tips are evenly distributed throughout the length of the brush box.

- Compress the cuttings tightly between the stakes and tie the pair of stakes and cuttings together with a strong galvanized wire. Wrap the wire tightly around the stakes at the notches and twist the wire between the stakes to "cinch" the cuttings down. Drive the stakes further into the soil. This procedure will tighten the wires and compress the cuttings into the trench.

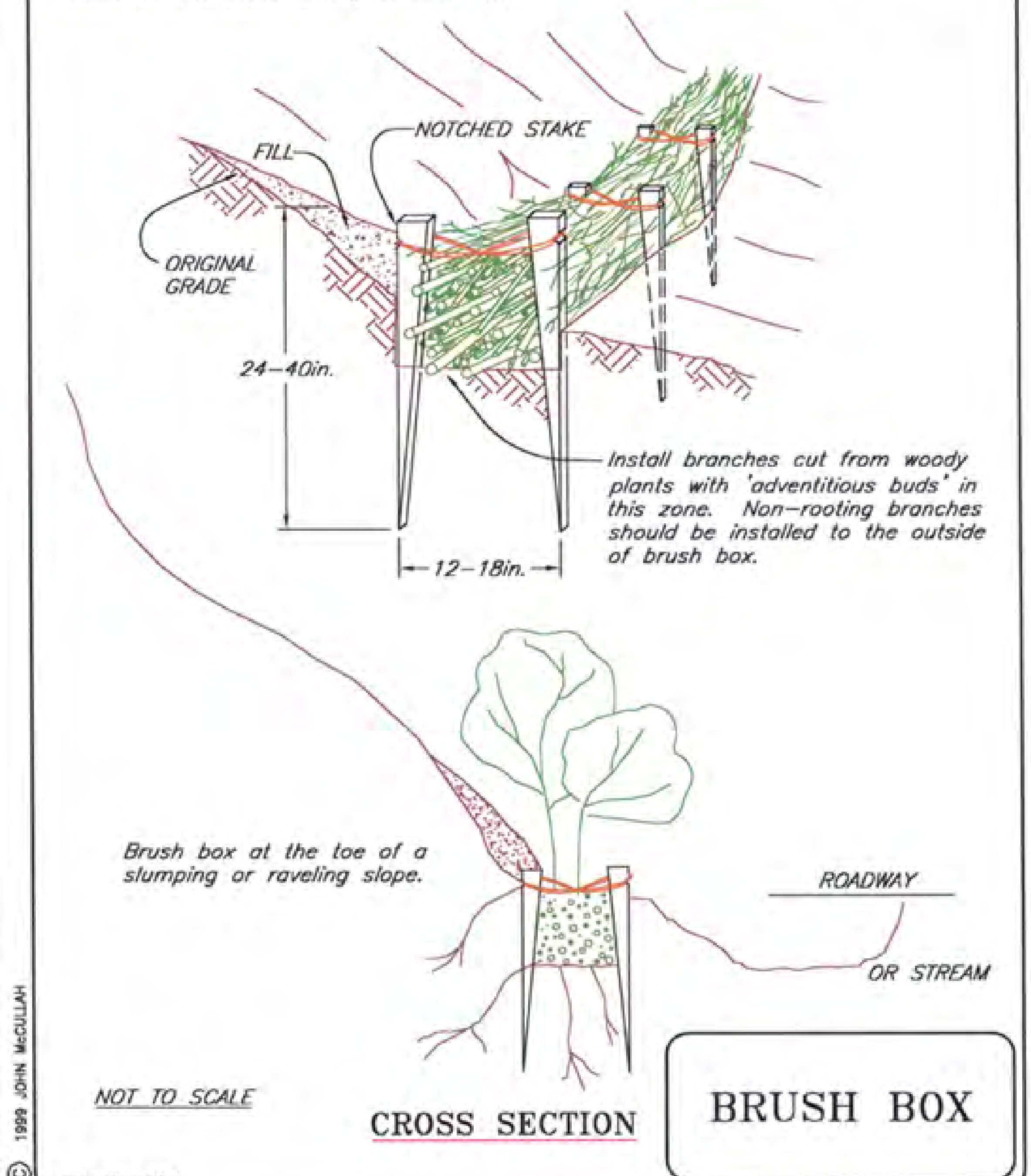
- Proper backfilling is essential to the successful rooting of the brush box. Backfill with soil graded from the slope above. Place moist soil along the sides of the live box. The backfill shall be worked into the cutting interstices during construction and compacted behind and below the bundle by walking on and working from brush box terrace.

- Repeat the proceeding steps to the top of the slope. The top of the brush box shall be slightly visible when the installation is completed.

Monitoring / Maintenance: Brush boxes shall be inspected every few weeks until well established, and irrigation, browse control (from livestock, deer, beavers, etc), pruning, weed control, and fertilization shall be implemented as needed.

Common Failures: A frequent cause of failure is poor maintenance.

NOTES:
1. Branches from non-rooting species may be combined when woody plants capable of vegetative propagation (Salix sp., Populus sp., Cornus sp.) are in short supply.
2. Proper backfilling is essential to the successful rooting of the brush box. Backfill with soil from slope above. The backfill must be 'worked' into the branches interstices during construction.



FASCINES WITH SUBDRAINS – EP-18

Application: Fascines with subdrains is an erosion prevention system for use in filled gully areas or tributary swales where groundwater is likely to collect and concentrate. The BMP is one of several soil bioengineering techniques to arrest and prevent slope failures and erosion; also used to enhance wildlife habitat and be aesthetically pleasing. Live fascines are intended to establish shrubs for biotechnical erosion control and are not removed at the end of construction.

Design Guidelines: Rows of fascines are installed on the contour of a slope in the conventional manner. In addition, a subsurface drain, oriented downslope and perpendicular to the fascines, is placed in a trench beneath the rows of fascines to intercept and collect seepage. The subsurface drain consists of a perforated pipe wrapped in a geo-composite drainage medium placed at the bottom of a trench. The trench is backfilled with clean, coarse aggregate or gravel.

The seepage collection trench is excavated first, and a perforated pipe wrapped in a composite geodrain is placed in the bottom of the trench. The trench is then backfilled with gravel or coarse aggregate. The fascines are installed over and across the trench and subsurface drain. Fascines are prepared and installed in the conventional manner as in EP-16. The geodrain is formed by first wrapping the perforated pipe in a three-dimensional open mat or matrix comprised of semi rigid polymeric fibers, e.g., Enkamat™, followed by another wrap of filter fabric or filter cloth. The porous core of the geocomposite shall face in towards the pipe, with the filter cloth backing facing outward. All drains shall be constructed and installed with clean-out access tubes. The perforated pipe in the subdrain shall have sufficient capacity to handle and transmit intercepted groundwater flow or seepage. Guidelines for computing the appropriate size can be determined from published nomographs. Normally, a 4-inch diameter polymeric pipe should suffice.

After construction of the drain trench, the live fascines are installed over the trench in the normal manner. Other than the presence of a clean out tube in the treatment including subsurface drainage, both techniques have the same external appearance.

Materials/Equipment: In addition to the live cuttings required for the fascines, materials are required for manufacturing the drains; that is, perforated polymeric pipe, filter cloth, and a turf reinforcement mat (e.g., Enkamat™) for wrapping the pipe. Stakes must not be allowed to dry out. All cuttings shall be soaked in water for 5-7 days (a minimum of 24 hours) and planted the same day they are removed from the water.

Construction Specifications/Installation:

- The seepage collection trench is excavated first, and a perforated pipe wrapped in a composite geodrain is placed in the bottom of the trench.
- The trench is then backfilled with gravel or coarse aggregate.
- The fascines are installed on contour over and across the trench and subsurface drain. Row spacing guidelines for fascine installations are presented in Table EP-18.1.

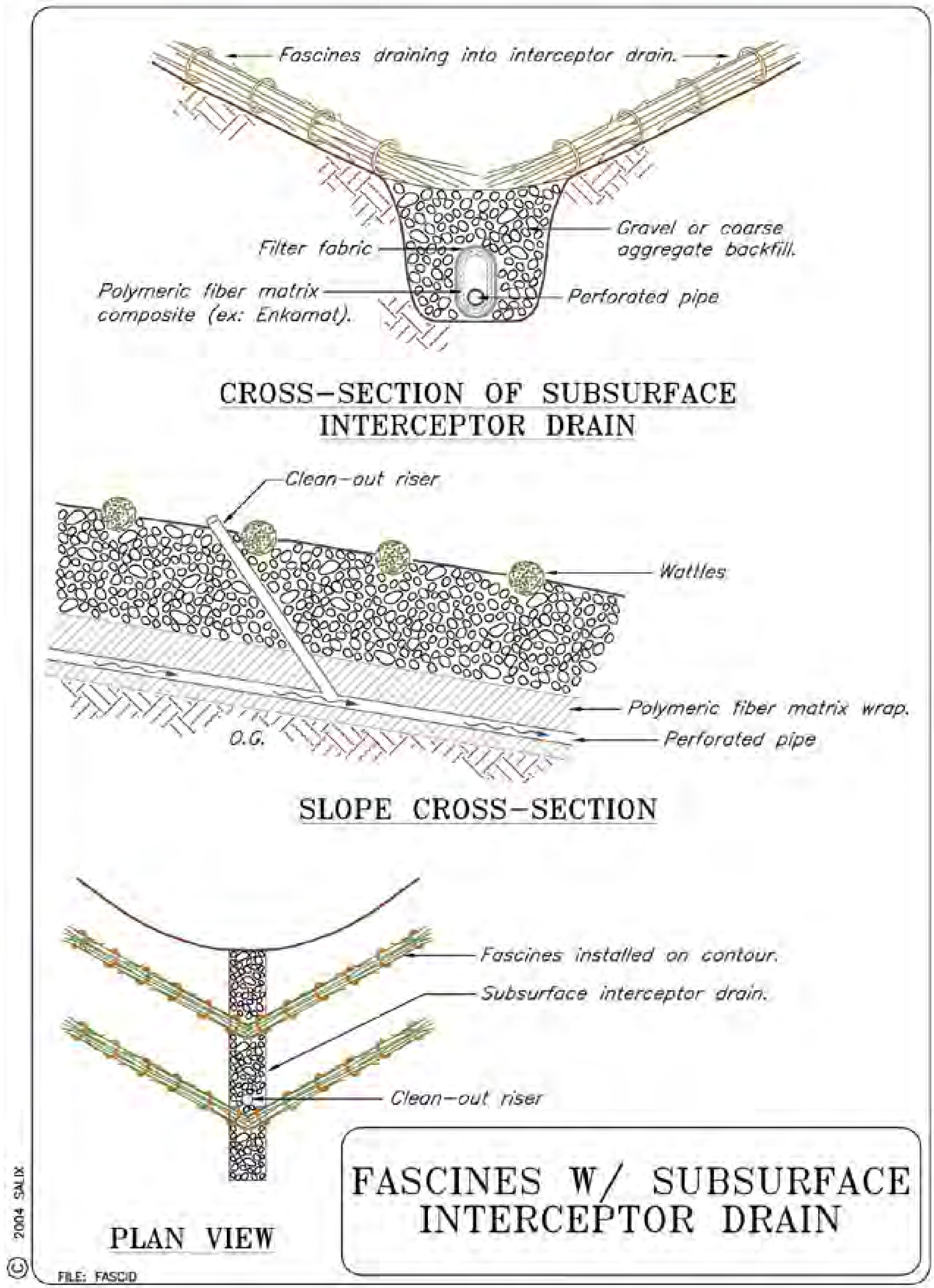
TABLE EP-18.1. RECOMMENDED SPACING FOR LIVE FASCINES ON SLOPES		
Slope Steepness (H:V)	**Slope Distance Between Fascine Rows (ft)**	
	On Contour	**On Angle**
1:1 to 1.5:1	3-4	2-3
1.5:1 to 2:1	4-5	3-5
2:1 to 2.5:1	5-6	3-5
2.5:1 to 3:1	6-8	4-5
3.5:1 to 4:1	8-9	5-7
4.5:1 to 5:1	9-10	6-8

Monitoring / Maintenance:

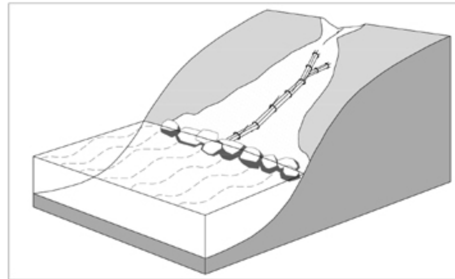
- The exit end of the subsurface drain shall be checked periodically to insure that water is flowing out of the drain.
- The subsurface drain pipe shall be flushed via the clean-out access tube as-needed if inspection indicates that the drain may be clogged. Flushed materials typically consist of excess groundwater and shall be disposed of properly based on site specific conditions and local requirements.

Common Failures: The most common reasons for failure are improper design of the interceptor drain placed at the bottom of the axial trench. The perforated pipe shall be correctly sized and wrapped with a suitable geodrain composite that excludes fines but that lets water through. Failure to inspect and flush the drain via the clean-out access tube, as needed, can lead to prolonged clogging and poor performance.

Another frequent cause of failure is poor maintenance.


Fascines draining into interceptor drain.
Gravel or coarse aggregate backfill.
Filter fabric
Polymeric fiber matrix composite (ex: Enkamat).
Perforated pipe
CROSS-SECTION OF SUBSURFACE INTERCEPTOR DRAIN
Clean-out riser
Wattles
Polymeric fiber matrix wrap.
O.G.
Perforated pipe
SLOPE CROSS-SECTION
Fascines installed on contour.
Subsurface interceptor drain.
Clean-out riser
PLAN VIEW
FASCINES W/ SUBSURFACE INTERCEPTOR DRAIN
© 2004 SALIX
FILE: FASCID

LIVE POLE DRAINS – EP-19



Application: Live pole drains are drainage systems composed of bundles of live willow (*Salix* spp.) branches (live fascines or willow wattles) placed in areas where excess soil moisture results in soil instability. They are intended to drain excess water away from an unstable bank. The BMP is one of several biotechnical erosion control (also known as soil bioengineering) techniques to arrest and prevent slope failures and erosion; also used to enhance wildlife habitat and be aesthetically pleasing because the willows are expected to sprout and grow.

Design Guidelines: Live pole drains are most applicable on streambanks and slopes where excessive soil moisture is causing piping, erosion, or slumping gullies. Live pole drains tend to be used most frequently on outer bends.

When designing a project, one must decide whether to use willow wattles or live fascines. Both are constructed of the same size poles, and in the same manner, with the exception of the orientation of the cuttings. Fascines have all the cuttings oriented one way (all butt ends together), while wattles are composed of poles oriented in both directions.

The use of live fascines will facilitate rooting, as cuttings grow best when the tips are pointed uphill. The use of willow wattles, on the other hand, will provide more efficient drainage, as half of the tapering tips are pointed downward, but rooting success will likely be lower. Therefore, one must decide whether the goal of the project is drainage or plant establishment.

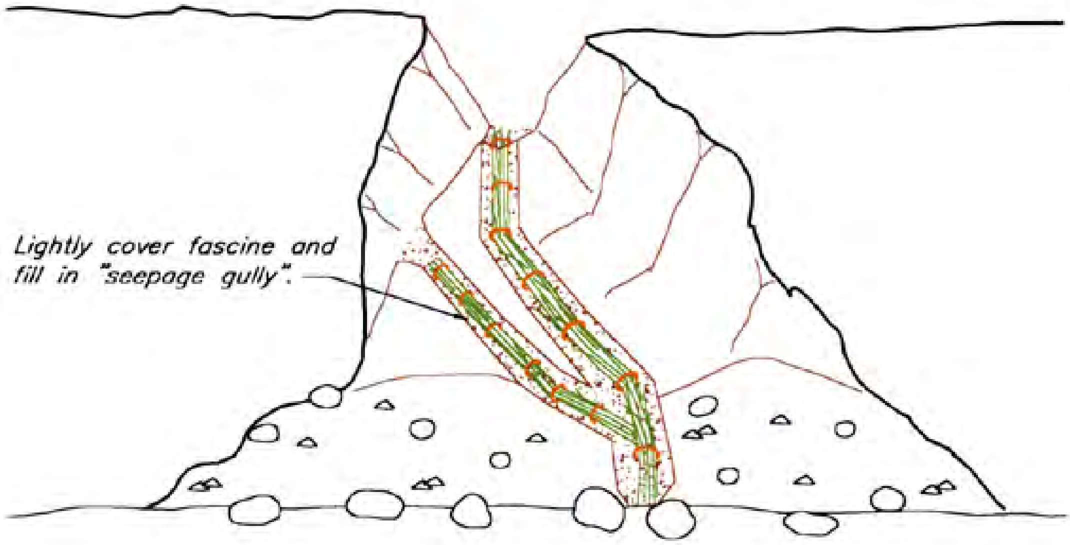
Materials/Equipment: Live Pole Drains are essentially willow wattles or fascines constructed with longer than usual poles, with many of the branches left on, and staked with live willow stakes, construction stakes, or a combination of the two. Stakes must not be allowed to dry out. All cuttings shall be soaked in water for 5-7 days (a minimum of 24 hours) and planted the same day they are removed from the water.

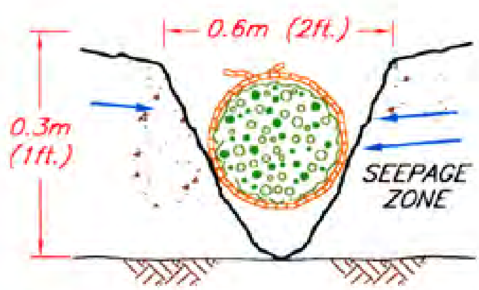
Construction Specifications/Installation:

- Place the wattles or fascines in an excavated trench or existing drainage gully in an area of seepage, such that they intercept and control excess moisture on the bank.
- Key the bundles into each other by jamming the ends together firmly and stake into place with live or inert stakes at 3-6 foot intervals.
- Stakes shall be placed near rope ties and in transitional areas for additional support.

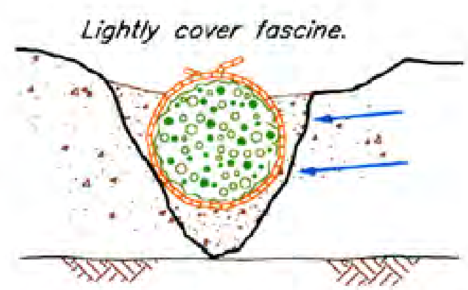
Monitoring/Maintenance: Regular inspection and maintenance of wattle installations shall be conducted, particularly during the first year, and repairs shall be made promptly. Any stakes that loosen because of saturation of the slope or frost action shall be re-installed. Rills and gullies around or under wattles shall be repaired using Brush Packing or Live Gully Fill Repair (EP-20), as necessary. All temporary and permanent erosion and sediment control practices shall be maintained and repaired to assure continued performance of their intended function.

Common Failures: Inappropriately using a subsurface drainage technique—Live Pole Drains—when a surface runoff control measure is necessary. Another frequent cause of failure is poor maintenance.





Excavate a shallow trench or utilize existing "seepage gully" (small<2ft.^{2}).



Place bundle of cuttings (fascine) in the trench and lightly backfill with native material.

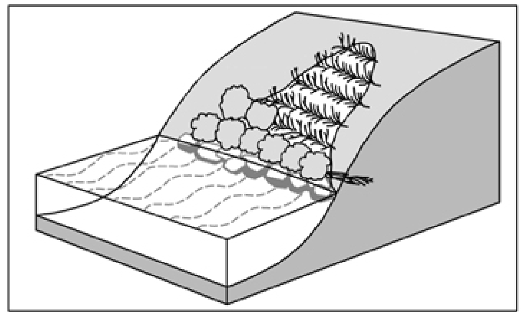
NOTES:

1. Live pole drain is a biotechnical technique which drains excess moisture from the bank and provides an initial cover of woody vegetation.
2. The cuttings used to form the fascines are intended to sprout and grow while the excess moisture continues to drain from the lower end.

LIVE POLE DRAIN

FILE: LIVE POLE DRAIN

BRUSH PACKING OR LIVE GULLY FILL REPAIR – EP-20



Application: In general, Brush Packing or Live Gully Fill Repair consists of a combination of techniques for stabilizing eroding intermittent or ephemeral channels. These repair techniques taken together include grading, installing drainage and fill, live cuttings, and surface erosion control. Brush Packing or Live Gully Fill Repair (also called brushlayering) consists of alternating layers of live branch cuttings and compacted soil. This reinforced fill can be used to repair small gullies. The method is similar to branch packing (a method for filling small holes and depressions in a slope), but is more suitable for filling and repairing elongated voids in a slope, such as gullies. The BMP is one of several biotechnical erosion control (also known as soil bioengineering) techniques to arrest and prevent slope failures and erosion; also used to enhance wildlife habitat and be aesthetically pleasing.

Design Guidelines:

- Live Gully Fill Repair is useful for gullies up to 1-6 feet in depth and up to 30 feet long.
- This repair technique shall only be used in channels with intermittent flows. The erosion processes at work in the incised channel or gully, must be correctly identified and understood to make a successful repair.

This technique is used to fill small gullies in natural slopes and streambanks.

- Fill placed in the channel shall consist of graded and well drained soil.
- Imbedded branches and their secondary roots will reinforce the backfill used to repair the gully and protect it against future washout and scour.
- A subsurface drain may be required if significant amounts of seepage or groundwater enters the gully at its head.
- Surface runoff entering the gully at its head shall be intercepted and diverted away from the area utilizing runoff controls such as pipe slope drains (RC-1), diversions (RC-3 and RC-4), or grass-lined channels (RC-5).

Gully treatment must include correcting or eliminating the initial cause of the gully as well as the gully itself. Accordingly, consideration shall be given to diverting excessive or concentrated runoff away from the gully head area. There may be side gullies that also require treatment; however, priority shall be given to the main channel.

Materials/Equipment:

- Graded and well drained soil for use as fill material.
- Live branch cuttings ranging from ½ to 2 inches in diameter.
- The branches shall be long enough to touch the undisturbed soil at the bottom (back) of the gully and to protrude slightly beyond the rebuilt slope face.

Construction Specifications/Installation: Live gully fill repair begins at the lowest point in the gully and proceeds upward. The live branches are inserted between successive lifts of lightly compacted soil. The following guidelines and procedures are recommended when installing a live gully fill repair system:

- Starting at the lowest point of the slope, place a 3-4 inch layer of branches at the lowest end of the gully and approximately perpendicular to the gully bottom (see Figure EP-20.1).

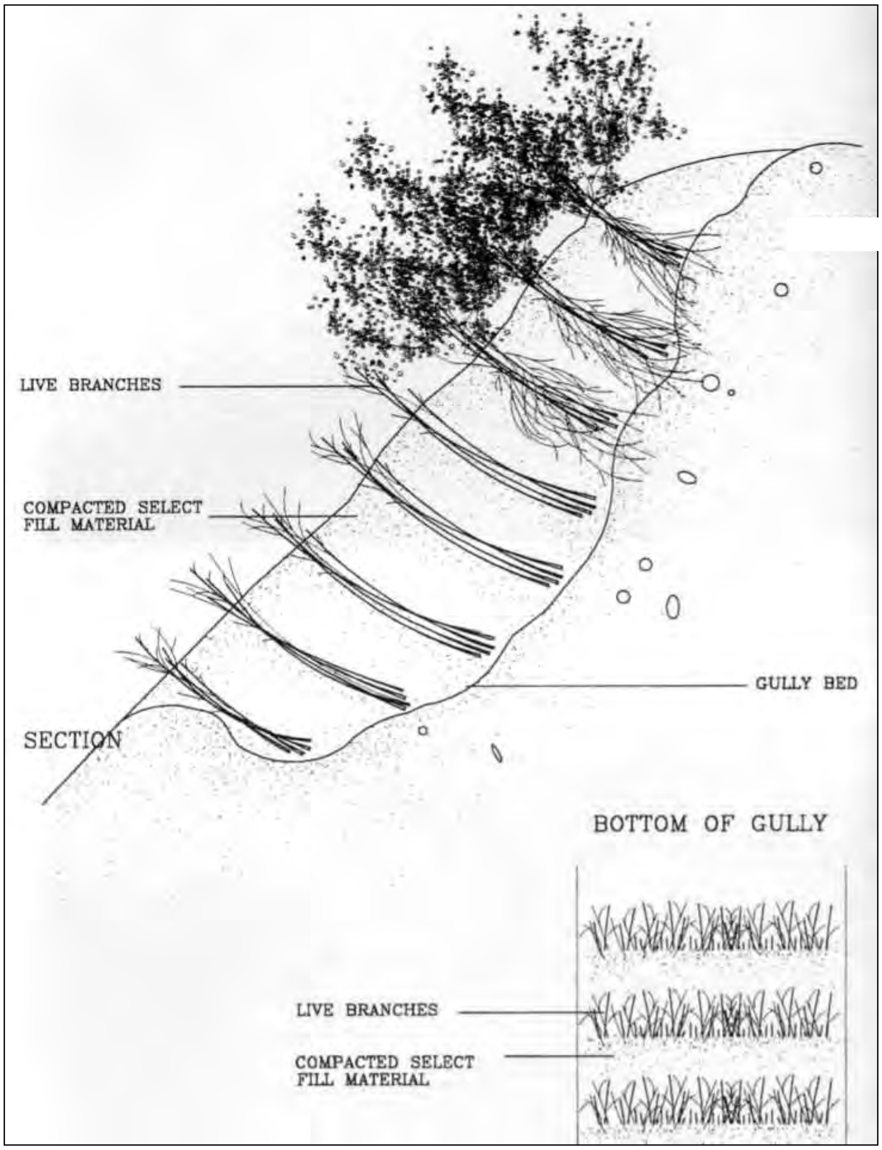
- Cover with a 6-8 inch thick of fill soil and compact
- Place the live branches in a crisscross fashion. Orient the growing tips toward the slope face with the basal ends lower than the growing tips.
- Follow each layer of branches with a layer of soil; work and compact the soil to ensure intimate contact with the branches and to eliminate large voids in the fill.

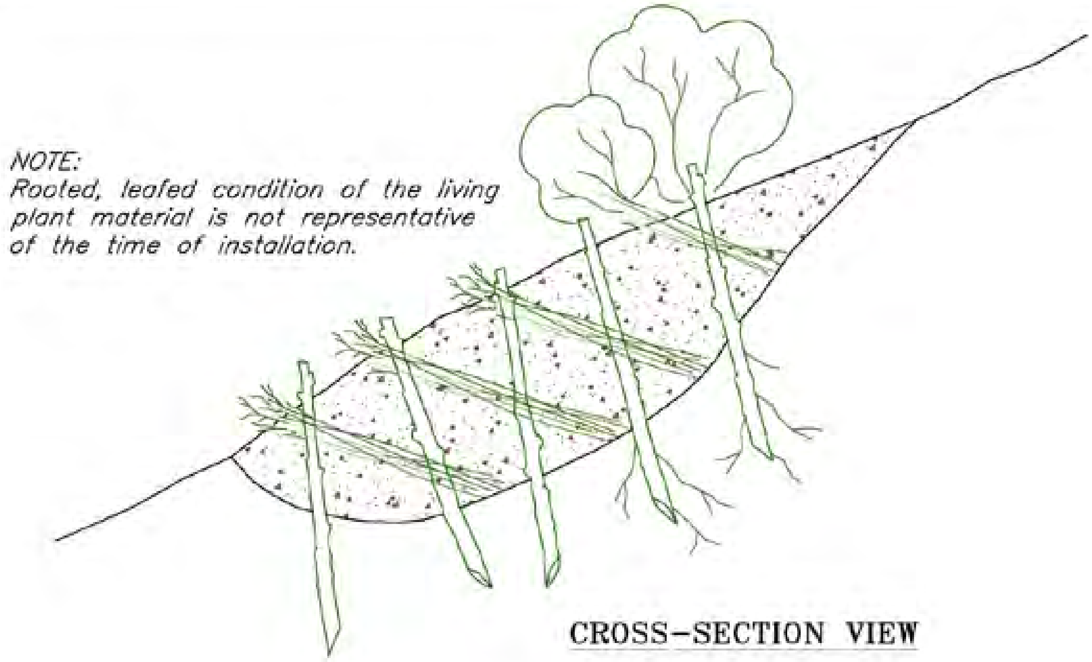
Monitoring / Maintenance:

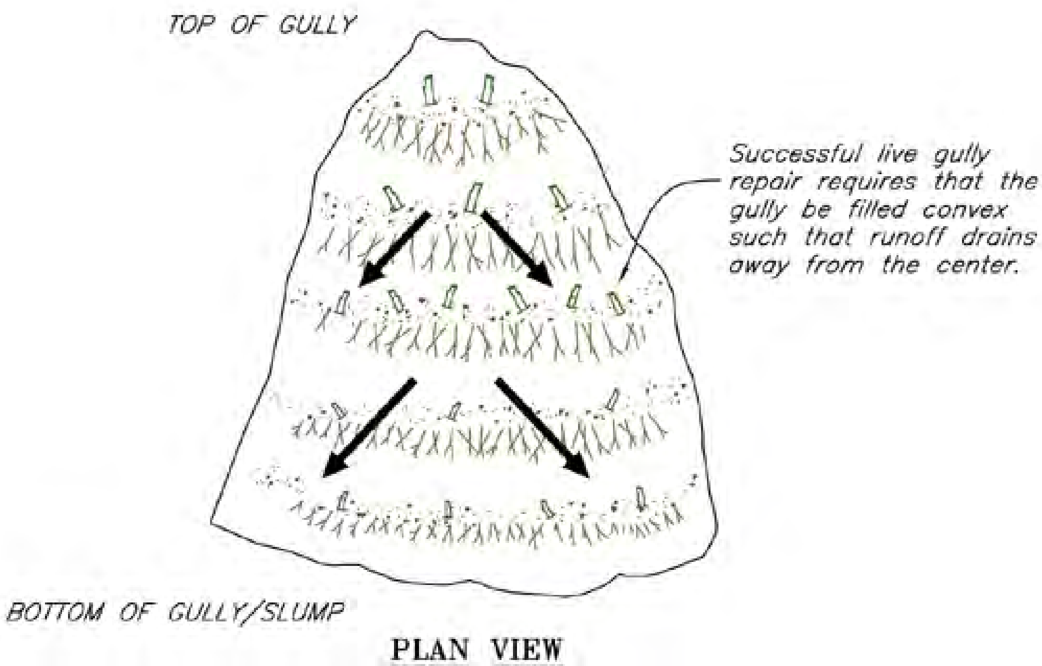
- Periodically check on stability of the fill within the repaired gully, particularly during the initial vegetative establishment period.
- Check for wet spots or seeps in the fill which indicate subsurface seepage problems. Examine the surface of the fill for evidence of runoff erosion such as rills.
- Make sure that runoff is diverted away from the fill during initial stages.

Common Failures: The main reason for failure of Brush Packing or Live Gully Fill Repair is saturation and washout of the earthen fill. Prevention of this outcome requires that seepage and runoff be excluded as much as possible from the fill area.
Another frequent cause of failure is poor maintenance.

FIGURE EP-20.1. ESTABLISHED LIVE GULLY FILL REPAIR.







LIVE GULLY FILL REPAIR

FILE: GULYRP

SODDING – EP-21

Application: Sodding is the placement of permanent grass cover that has been grown elsewhere and brought to the site. Sodding stabilizes an area by immediately covering the soil surface with "sheets" of pre-established grass, thereby protecting the soil from erosion, enhancing infiltration, filtering sediment and other pollutants, and slowing runoff velocities.

Design Guidelines: Sodding is appropriate for areas that contained turf or grasses before construction; any graded or cleared area that might erode; and areas where a permanent, long lived plant cover is needed immediately. Sodding may be used in vegetative buffer zones, stream banks, grassed dikes, swales, slopes, outlets, level spreaders, and filter strips and is particularly effective on flood plains, areas adjacent to wetlands or other sensitive water bodies, and on steep, unstable slopes. Natural revegetation may be more appropriate for areas not prone to erosion and where there is an available seed source.

Materials/Equipment: Sod shall be healthy and field grown, containing thatch not more than ½-inch thick. The age of the sod shall be between 8 and 16 months old. The sod shall be free from disease, weeds, insects, and undesirable types of grasses and clovers and grown in accordance with any applicable agricultural requirements. Soil upon which the sod was grown shall contain less than 50% silt and clay. Sod shall be machine cut at a uniform soil thickness of 0.625 inches ±0.25-inch, excluding top growth and thatch. A certificate of compliance for the sod shall be furnished to the contractor.

Construction Specifications/Installation:

- Sod shall be protected with tarps or other protective covers during delivery and shall not be allowed to dry out between harvesting and placement.
- All weeds and debris shall be removed before cultivation of the area to be planted and properly disposed.
- After cultivation, installation of irrigation systems, and rough grading are completed, areas to be planted with sod shall be fine graded and rolled. Topsoil may be needed in areas where the soil type and texture are inadequate. Areas to be planted with sod shall be smooth and uniform before placing sod. Areas to be planted with sod adjacent to sidewalks, concrete headers, header boards, and other paved border and surface areas shall be 1.5 inches ± 0.25-inch below the top grade of such facilities after fine grading, rolling, and settlement of the soil. Sod shall be placed so that ends of adjacent strips of sod are staggered at least 24 inches. All edges and ends of sod shall be placed firmly against adjacent sod and against sidewalks, concrete headers, header boards, and other paved borders and surfaced areas.
- After placement of the sod, the entire sodded area shall be lightly rolled to eliminate air pockets and ensure close contact with the soil. After rolling, the sodded areas shall be watered so the soil is moistened to a minimum depth of 4 inches. Sod shall not be allowed to dry out, planted during very hot or wet weather, or placed on slopes that are greater than 3H:1V if they are to be mowed.
- If irregular or uneven areas appear before or during the plant establishment period, such areas shall be restored to a smooth and even appearance.
- The sod (turf) shall be allowed to grow to 3 inches high. When the turf reaches this height, it shall be mowed to a height of 1 inch or as recommended by the grower of the sod. All turf edges—including edges adjacent to sidewalks, concrete headers, header boards, and other paved borders and surfaced areas—shall be trimmed to uniform edge not extending beyond the edge of turf or such facilities.
- Mowed and trimmed growth shall be removed and disposed of outside the project. Trimming shall be repeated whenever the height of the turf exceeds 1 inch.

Monitoring/Maintenance:

- Inspect sod installations weekly and after significant storm events, until the turf is established.

- Maintenance shall consist of mowing, weeding, and ensuring that the irrigation system is operating properly and as designed to sustain growth.

Common Failures:

- Insufficient moisture, or temperature that is too hot or cold.
- Improper site preparation.
- Poor sod quality.

SOIL STOCKPILE MANAGEMENT – EP-22

Application: Soil stockpile management procedures and practices are designed to reduce or eliminate air and stormwater pollution from temporary stockpiles of soil, which are susceptible because slopes may be steep and soil may be recently disturbed. For topsoil stockpiles, see EP-4.

Design Guidelines: Locate temporary stockpiles at least 50 feet away from inlets, drainage courses, or water bodies. Stockpiles shall be seeded for vegetation or covered with plastic sheeting.

Materials/Equipment: Earthmoving equipment, temporary erosion control seed mix, plastic sheeting, tape, stakes, weights (anchors), and rope.

Construction Specifications/Installation:

- Limit soil stockpile height to 15 feet, unless City approves taller stockpile.
- Perimeter sediment control (e.g., berm, sediment fence, fiber rolls, or gravel bags) at the toe of slope shall be installed at soil stockpiles year round.
- Protect storm drain inlets, drainage courses, and receiving waters from soil stockpile erosion, using drain inlet protection and perimeter sediment controls, as appropriate.
- Implement dust control practices, as appropriate, to prevent wind erosion of stockpiled soil material.

Vegetation Cover:

- At the onset of inactivity or upon completion of final grading, apply temporary seeding within 14 days during the wet season (October 1st through May 31st) or within 30 days during the dry season (June 1st through September 30th).
- Follow additional seeding specifications in Temporary Seeding and Planting (EP-5).

Plastic Sheeting Cover:

- Avoid using plastic sheeting on soil stockpiles located above steep or unstable slopes that may be adversely affected by concentrated runoff.
- Use 6-millimeter plastic or comparable material. Overlap seams 1-2 feet. Tape, roll, and stake the seams.
- Weigh down the entire length of plastic. Anchor the plastic using sandbags or other suitable tethered anchoring system spaced on 10-foot grid spacing.

Additional Measures for Steep Slope Protection:

- When possible, install a diversion dike (RC-4) at the top of the plastic to divert flows away from the slope.
- Toe-in the top of the plastic sheeting in a 6-inch x 6-inch trench, backfilled with compacted native material.
- Install augmented perimeter sediment control (e.g., gravel berm, riprap, or other suitable protection) at the toe of the slope to dissipate runoff velocity.

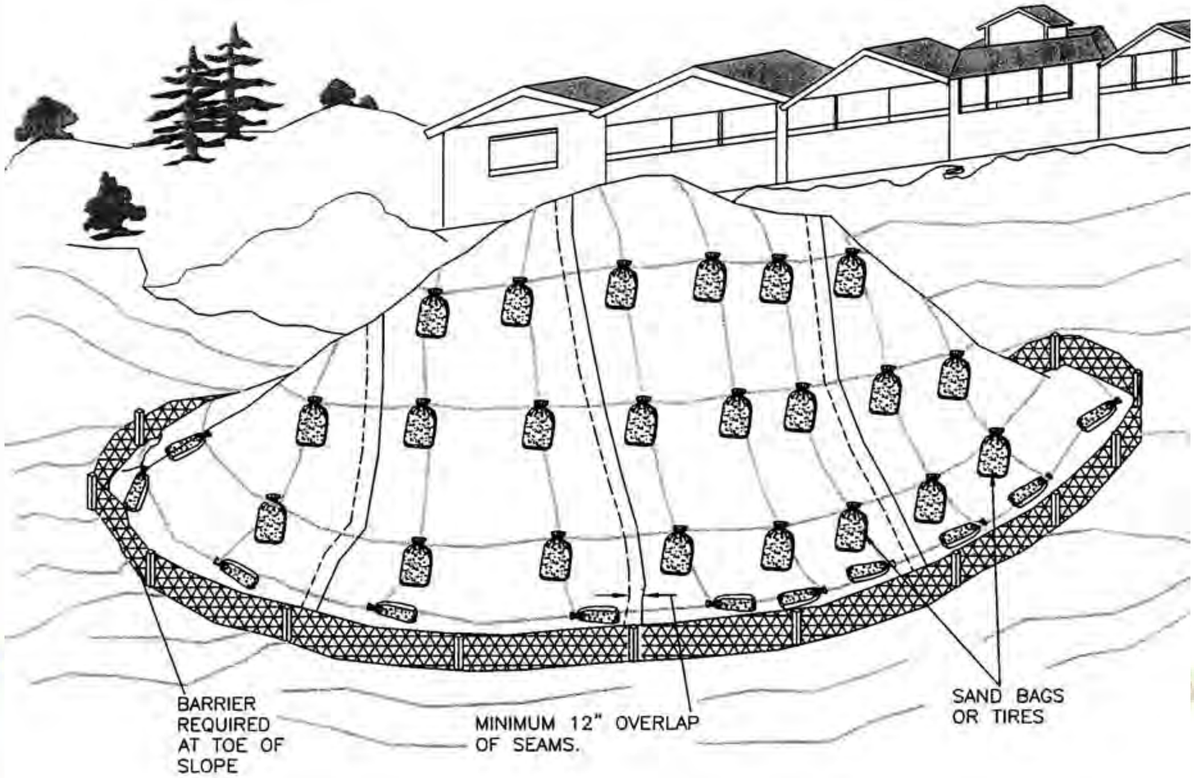
Monitoring/Maintenance:

- Inspect stockpiles regularly, and prior to and after storm events.
- Repair rills and gullies of vegetated stockpiles.
- Check plastic anchoring system and repair or add anchors, as needed.

- Replace torn sheeting and repair open seams.
- Completely remove plastic after it is no longer needed.

Common Failures:

- Seeded too late for germination before cold weather.
- Poorly installed plastic sheeting and anchor system.
- Erosion hazard due to water sheet flowing off plastic at high velocity.
- Lack of maintenance.



PLASTIC SHEETING

NOTES:

1. MINIMUM 12" OVERLAP OF ALL SEAMS REQUIRED.
2. BARRIER REQUIRED @ TOE OF STOCK PILE.
3. COVERING MAINTAINED TIGHTLY IN PLACE BY USING SANDBAGS OR TIRES ON ROPES WITH A MAXIMUM 10' GRID SPACING IN ALL DIRECTIONS.

SOIL STOCKPILE MANAGEMENT WITH PLASTIC SHEETING	**EP-22**

EPSC Details
For Runoff Control

SLOPE DRAIN – RC-1

Application: Slope drains (and subsurface drains) are used to intercept and direct surface runoff or groundwater into a stabilized watercourse, trapping device, or stabilized area. Also refer to BMP EP-19, Live Pole Drains.

Design Guidelines: Slope drains are constructed with pipes or lined channels that convey surface runoff down slopes without causing erosion.

Materials/Equipment:

Slope Drains are constructed from flexible down drain, plastic pipe, or sewn filter fabric, and are used to direct concentrated flows down slopes without causing erosion to exposed or stabilized slopes.

Subsurface drains are constructed from tile, pipe, or tubing and are used to improve drainage and stabilize slopes in areas with saturated soils.

Construction Specifications/Installation:

- Place slope drains on undisturbed soil or well-compacted fill at locations and elevations shown on plans.
- Slightly slope the section of pipe under the dike toward its outlet.
- Compact the soil under and around the entrance section in lifts not to exceed 6 inches.
- Ensure that fill over the drain at the top of the slope has a minimum depth of 1.5 feet and a minimum top width of 4 feet. The sides should have a 3H:1V slope.
- Ensure that all slope drain connections are watertight.
- Ensure that all fill material is well-compacted. Securely fasten the exposed section of the drain with grommets or stakes spaced no more than 10 feet apart. If the drain is longer than 10 feet, the drain must be anchored within each 10 foot section and at the end section. Anchoring methods can vary depending on site conditions. At a minimum, the drain shall be staked such that it is not able to move laterally or separate from the upstream diversion culvert.
- Extend the drain beyond the toe of the slope and adequately protect the outlet from erosion (see RC-2, Energy Dissipater/Outlet Protection).
- Make the settled, compacted dike ridge no less than 1 foot higher than the top of the pipe inlet.
- Immediately after grading, stabilize all disturbed areas as appropriate (see Erosion Prevention BMPs).

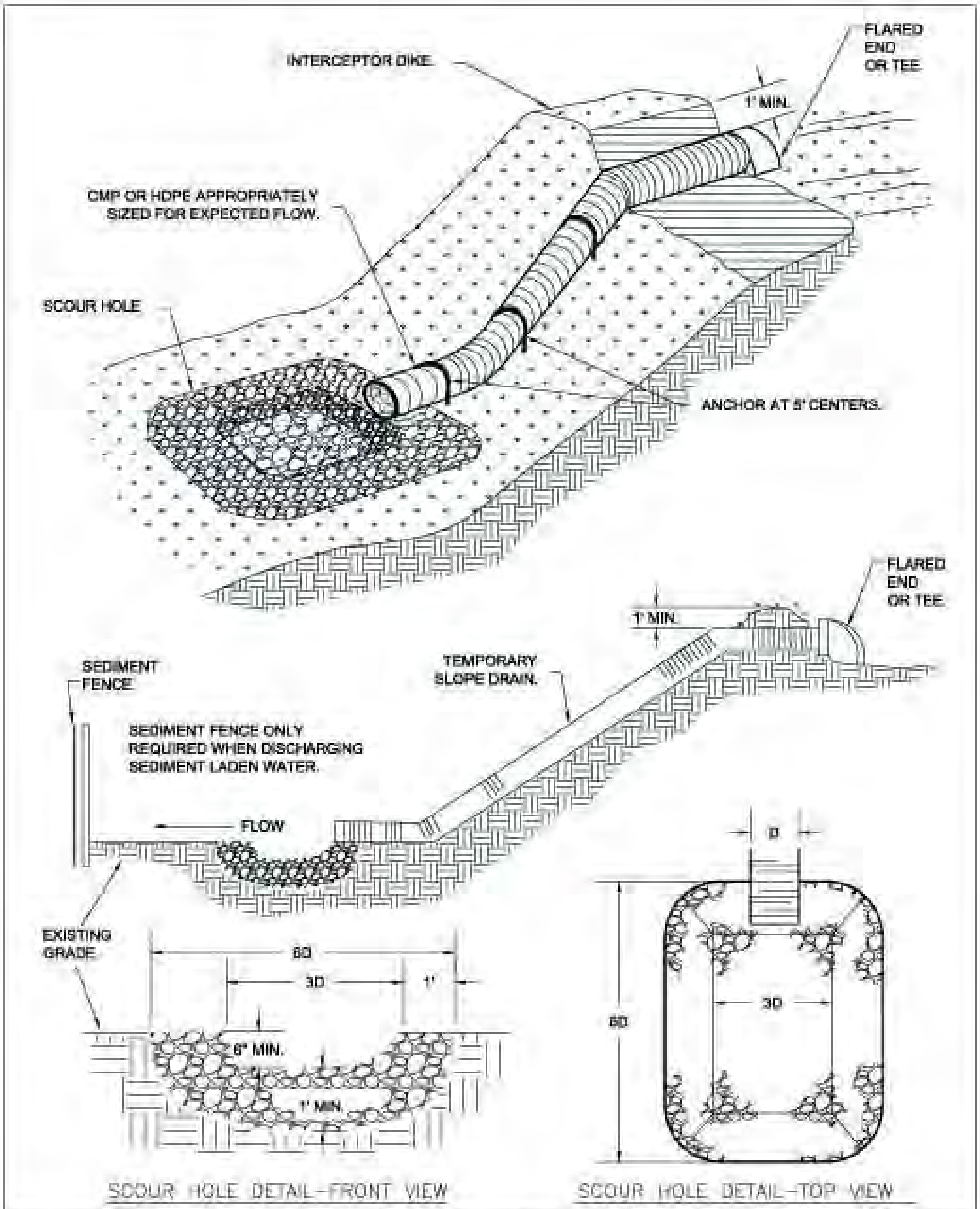
Monitoring/Maintenance: Inspect the slope drain and supporting diversions before, during, and after every storm event and promptly make necessary repairs. When the protected area has been permanently stabilized, remove the temporary measures, dispose of the materials properly, and stabilize disturbed areas appropriately.

Common Failure: Caused by water saturating the soil and seeping along the pipe. Reduce potential failure by properly backfilling around and under the pipe haunches with stable soil material and hand compacting in 6-inch lifts to achieve firm contact between the pipe and the soil at all points.

Alternative: As an alternative to slope drains, visqueen flume down drains may be used to convey runoff to a stabilized downstream conveyance. The visqueen shall be anchored at the top of a slope similar to erosion control blankets (EP-10). Use sandbags to stabilize the sides of the visqueen flume similar to sand bag barriers (SC-2). The visqueen (plastic sheet) shall meet the following specifications:

- Plastic sheeting shall have a minimum thickness of 6 mil, and shall be keyed in at the top of slope and firmly held in place with sandbags or other weights placed no more than 10 feet apart. Seams shall overlap at least 12 to 24 inches and taped or weighted down their entire length. Edges shall be embedded a minimum of 6 inches in the soil.

- After installation all sheeting shall be inspected periodically and after significant rainstorms to check for erosion, undermining, and anchorage failure. Any failures shall be repaired immediately. If washout or breakages occur, the material shall be reinstalled after repairing the damage to the slope.



PIPE SLOPE DRAIN	RC-1

ENERGY DISSIPATER/OUTLET PROTECTION – RC-2

Application: Velocity dissipation and outlet protection devices are physical structures such as rock riprap, stone, or concrete flow spreaders placed at the outlet of drainage culverts and channels to reduce the velocity and/or energy of the exiting water.

Design Guidelines: This BMP provides specifications for riprap type energy dissipaters. Alternative energy dissipation methods such as mats, plates, or other stabilization techniques may be used in the project Erosion Prevention and Sediment Control Plan as approved by the City.

Materials/Equipment:

- Riprap may be field stone or rough quarry stone. It shall be hard, angular, highly weather-resistant and well graded. Riprap size to be determined by project engineer and must meet City specification requirements.

Construction Specifications/Installation:

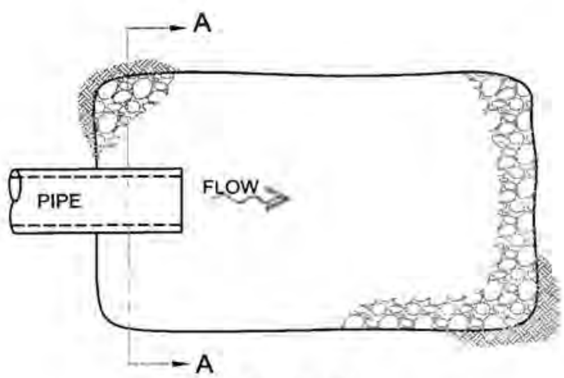
- Ensure that the subgrade for the filter and riprap follows the required lines and grades shown on the plans. Compact any fill required in the subgrade to the density of the surrounding undisturbed material. Low areas in the subgrade on undisturbed soil may also be filled by increasing the riprap thickness.
- The riprap and gravel filter must conform to the specified grading limits shown on the plans.
- Filter fabric, when used, must meet design requirements and be properly protected from punching or tearing during installation. Repair any damaged fabric by removing the riprap and placing another piece of filter fabric over the damaged area. All connecting joints shall overlap a minimum of 1 foot. If the damage is extensive, replace the entire filter cloth.
- Riprap may be placed by equipment, but take care to avoid damaging the fabric.
- The minimum thickness of the riprap shall be 1.5 times the maximum stone diameter.
- Construct the apron on a zero grade with no overflow at the end. Make the top of the riprap at the downstream end level with the receiving area or slightly below it.
- Ensure that the apron is properly aligned with the receiving stream and preferably straight throughout its length. If a curve is needed to fit site conditions, place it in the upper section of the apron.
- Immediately after construction, stabilize all disturbed areas with vegetation.
- Outlets of all water conveyances must be stabilized.

Monitoring/Maintenance:

- Inspect riprap outlet structures before, during, and after rains to see if any erosion around or below the riprap has taken place or if stones have been dislodged. Immediately make all needed repairs to prevent further damage.
- Clean out energy dissipation as necessary when approximately half of the void space is filled with sediment and debris.

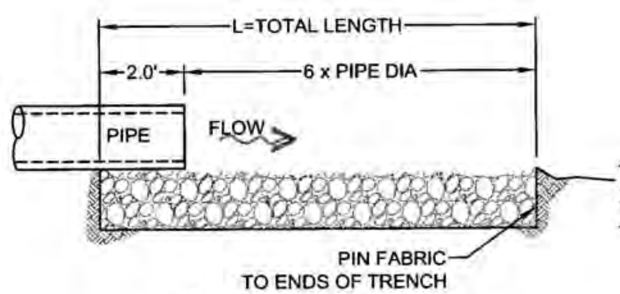
Common Failures:

- Tearing filter fabric during installation.



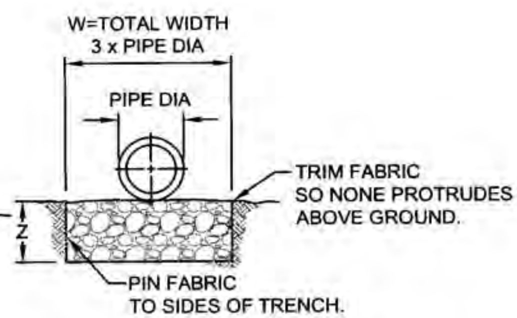
PLAN VIEW

NTS



PROFILE VIEW

NTS



SECTION A-A

NTS

ROCK SIZE-CLASS	Z TRENCH DEPTH RANGE	TYPE OF FABRIC (NON-WOVEN OR WOVEN)
25 Lb	10"-16"	NW OR W
75 Lb	1.0'-1.5'	NW OR W
200 Lb	1.5'-2.0'	W
1/4 TON	2.5'-3.0'	W
1/2 TON	3.0'-4.0'	W
1 TON	4.0'-5.0'	W

ENERGY DISSIPATER/OUTLET PROTECTION	**RC-2**

TEMPORARY DIVERSION SWALE – RC-3

Application: A diversion swale is a small excavated channel lined with grass, matting, or riprap. Swales are used to convey runoff down sloping land or divert runoff away from a sensitive area or steep slope to avoid erosion. These structures can be used to direct runoff to a stabilized outlet, watercourse, drainage pipe, channel, or sediment-trapping device.

Alternative: Alternatives to Diversion Swale techniques are Slope Drains (RC-1), Temporary Diversion Dikes (RC-4), and Grass-Lined Channels (RC-5).

Design Guidelines: Diversion swales intercept, divert, and convey surface run-on—generally sheet flow—to prevent erosion and transport of pollutants through and from the site. Construct diversion swales to intercept and divert run-on to avoid sheetflow over sloped surfaces and work areas.

Materials/Equipment: Excavation equipment and seed, riprap, or matting. Check dams (RC-11) shall be installed as necessary to reduce velocity.

Construction Specifications/Installation:

- Construct diversion swale to adequately divert storm flows based on careful evaluation of the risks due to erosion of the measure, soil types, over topping, flow backups, washout, and drainage flow patterns for each project site.
- Soil stabilization (e.g., vegetation (EP-5 and EP-6), blankets (EP-10), riprap) is required to prevent scour in the swale. Additional velocity controls (e.g., check dams) may be necessary.
- Correctly size and locate swales. See Table RC-3.1. Excessively steep, unlined dikes and swales are subject to erosion and gully formation.

TABLE RC-3.1. TEMPORARY DIVERSION SWALE DESIGN CRITERIA

Bottom Width	24-inch minimum, level bottom	
Depth	12-inch minimum	
Side Slopes	Less than 2H:1V	
Slope Grade	5% maximum with positive grade to suitable outlet	
Slope of Disturbed Area vs. Horizontal Spacing	< 5%	300 feet
	5 to 10%	200 feet
	10 to 25%	100 feet
	25 to 50%	50 feet
Slope Stabilization	Vegetation, matting, or 12 inches of riprap pressed into bank 3-4 inches	
Outlet	Level spreader or riprap to stabilized outlet or sediment pond	

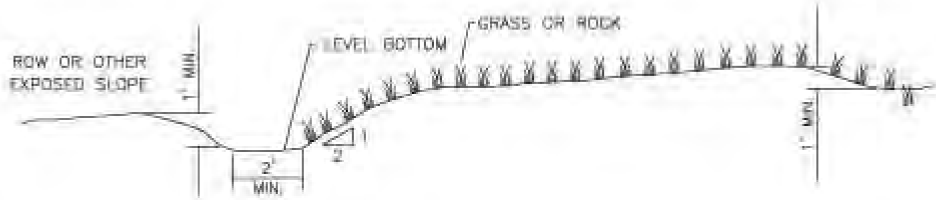
- The swale shall have a level 2-foot-wide bottom with side slopes no greater than 2H:1V.
- The grade shall not exceed 5 percent with a positive drainage to a stabilized or suitable outlet.
- Divert runoff to an appropriate downstream location. Do not divert runoff to adjacent properties without permission.

- Use flow spreaders to convert concentrated runoff into sheetflow prior to discharge onto areas stabilized by existing vegetation and intermittently throughout the swale.
- Install swales early in the construction process. Utilize permanent systems when applicable.
- Convey collected run-on/concentrated flows down slopes in accordance with the RC-1, Slope Drains.
- Provide stabilized outlets. Refer to Energy Dissipater/Outlet Protection (RC-2).

Monitoring / Maintenance:

- Inspect swales regularly for erosion, debris, and sediment; and before, during, and after rain events. Repair as necessary.
- Temporary conveyances shall be completely removed as soon as the surrounding drainage area has been stabilized, or at the completion of construction.

Common Failure: Diverting runoff without providing soil stabilization, velocity, and sediment controls.



BOTTOM WIDTH	2 FEET MINIMUM, THE BOTTOM WIDTH SHALL BE LEVEL
DEPTH	1 FOOT MINIMUM
SIDE SLOPE	2H:1V OR FLATTER
GRADE	MAXIMUM 5 PERCENT, WITH POSITIVE DRAINAGE TO A SUITABLE OUTLET (SUCH AS SEDIMENTATION POND)

DIVERSION SWALE

TEMPORARY DIVERSION DIKE

Slope	Spacing
<5%	300 feet
5–10%	200 feet
10–40%	100 feet

NOTE:
IMMEDIATELY UPON CONSTRUCTION, ESTABLISHED VEGETATION OR EROSION CONTROL BLANKETS ARE REQUIRED.

DIVERSION DIKE / SWALE	RC-3 and RC-4

TEMPORARY DIVERSION DIKE – RC-4

Application: A temporary diversion dike is a low berm or ridge of compacted soil that channels water away from a steep slope or embankment and toward a desired location. The purpose of a diversion is to intercept and divert runoff away from the face of a steep slope or streambank.

Design Guidelines: Diverted runoff shall outlet onto a stabilized area, a prepared level spreader, or into a slope protection structure, e.g., a slope drain. Diversion dikes are constructed from compacted earthen fill and shall be used on drainage areas of 5 acres or less. In addition to protecting the face of a steep slope from overbank runoff, diversions may also improve general slope stability by preventing runoff from infiltrating into and saturating the face of the bank. Earth dikes shall be stabilized with vegetation.

Materials/Equipment: Construction of a low dike requires soil with sufficient fines to hold a 2H:1V side slope and to be relatively impermeable when compacted. The dike can be constructed by hand or with the aid of a backhoe or front-end loader.

Construction Specifications/Installation:

- Diversion dikes are constructed from compacted earthen fill to a height of 18 inches with side slopes 2H:1V or flatter. Height is measured from the upslope toe to the top of the dike. See Table RC-4.1 for design criteria.
- The dike shall have a minimum top width of 2 feet. A shallow trench or swale to contain the diverted runoff is normally incorporated into the design. Soil from the ditch shall be used to construct the berm, provided it has sufficient fines to hold a 2H:1V side slope and be relatively impermeable when compacted. The swale or drainage ditch must have positive drainage to an outlet. Vegetative or mechanical stabilization may be required where grades are excessive.
- If overbank runoff is a problem, construction of a diversion dike or interceptor shall precede other bank stabilization treatments.
- The height of the dike shall be kept below 18 inches so as not to interfere with bank access.
- Use of a ditch and bank combination allows more efficient capture and diversion of runoff.
- Soil excavated from the ditch can be used to construct the dike. Slope drains shall be inserted through the dike periodically to convey the collected runoff to an appropriate discharge point.
- The ditch shall be constructed with sufficient positive grade for discharge to an appropriate outlet.
- The Temporary Diversion Swale BMP (RC-3) can be used as an alternative design for RC-4.
- The BMP detail for RC-4 is provided with BMP RC-3.

Monitoring/Maintenance:

- The dike and/or berm shall be inspected to ensure that it has not been breached. Repair as needed or as directed. The swale behind the dike also shall be inspected for accumulation of sediment and debris. Excessive sediment accumulations shall be removed.

Common Failures:

- Overtopping and/or breaching of the dike or berm.
- Excessive sediment accumulation in the ditch or swale behind the berm.
- Inadequate or insufficient outlet capacity of any appurtenant drop inlet and/or slope drains.

TABLE RC-4.1. TEMPORARY DIVERSION DIKE DESIGN CRITERIA		
Top Width	24-inch minimum	
Height	12-inch minimum measured from upslope toe and at a 90% standard proctor compaction ASTM D698	
Side Slopes	Less than 2H:1V	
Slope Grade	Topography dependent	
Dike Grade	Between 0.1 and 1%	
Slope of Disturbed Area vs. Horizontal Spacing	< 5%	300 feet
	5 to 10%	200 feet
	10 to 25%	100 feet
	25 to 50%	50 feet
Slope Stabilization	< 5%: Seed and mulch within 5 days following dike construction	
	5 to 40%: Stabilize immediately sod, matting with seed, or riprap	
Outlet	Upslope side of dike provides positive drainage to the outlet. Provide energy dissipation as necessary to prevent erosion. Release sediment-laden runoff to a sediment–trapping facility.	

GRASS-LINED CHANNEL (TURF REINFORCEMENT MATS) – RC-5

Application: Turf Reinforcement Mats (TRMs) are designed to provide protection to resist channel and streambank erosion and are useful when channel soils may subside or shift after installation. Installation of grass-lined channels with TRMs is typically part of the permanent drainage design for a site or could be a temporary control for a long-duration construction project.

Design Guidelines: TRMs can be installed after applying seed to the prepared soil surface or deployed first, and then seeded following infilling with soil. The former method allows the roots and shoots to grow through and interlock with the geosynthetic matrix. The channel or bank surface requires careful preparation, must be uniform and relatively free of rocks, stumps, and clods to ensure that there is complete contact between the TRM and the soil surface.

Materials/Equipment: TRMs are similar to Erosion Control Blankets, but they usually are intended for lining channels (see EP-10 for slope installation techniques). They are composed of ultraviolet (UV) stabilized polymeric fibers, filaments, nettings and/or wire mesh, integrated together to form a three-dimensional matrix ¼ to ¾ in thick. The types of polymer include polypropylene, polyethylene, polyamides, and polyvinyl chloride. TRMs are often combined with organic material such as coir to aide vegetation establishment and provide the initial temporary erosion control necessary to resist erosion due to rain impact and runoff until the vegetation can become established. Typical vegetation includes grasses that can withstand inundation. TRMs may be installed either by hand labor or equipment; the main tools or equipment required consist of hammers, stapling devices, and shovels or equipment for trenching.

Construction Specifications/Installation: Select a type of TRM based on the site condition and shear stress, as shown in Table RC-5.1 below.

The number of anchoring stakes or staples per foot is site and product specific, and shall be determined according to the manufacturer's specifications. See Table RC-5.2 below for stake sizing recommendations. Live willow stakes may be substituted for metal or wooden anchoring stakes, although it should be noted that willows could shade out turf grass. Willow wattles or fascines may be used to anchor the mats into the slots.

TABLE RC-5.1. RECOMMENDATIONS FOR TRM APPLICATIONS (Erosion Control Technology Council, 2001)

Type	UV Stability Minimum tensile strength retained after 1000 hr. (ASTM D 4355) (%)	Tensile Strength[1,2] (ECTC[4] mod. ASTM D5035) lb/ft	Application	
			Slope H:V	Channel max. shear stress[3] (ASTM D6460 or other ECTC approved tests) lb/ft^2
A	80	125	1:1	6
B	80	150	0.5:1	8
C	80	175	0.5:1	10

[1] Minimum average roll values, machine direction.
[2] Field conditions with high loading and/or high survivability requirement may warrant the use of TRMs with tensile strength of 3000 lb/ft or greater
[3] Max. shear stress TRM (fully vegetated) can sustain without physical damage or excess erosion during a 30-minute flow event. (Note: fully vegetated shear stress properties for TRMs containing degradable components must be obtained on the non-degradable portion of the matting alone.)
[4] Erosion Control Technology Council – *Technical Guidance Manual for Testing Rolled Erosion Control Products*.

TABLE RC-5.2. RECOMMENDATIONS FOR TRM STAKE SELECTION

Stake Length	Soil Conditions
6 inches	Typical soil conditions. Six-inch staples used in all but loose soil types.
8 inches	Loam, relatively loose sandy loam to sandy soils. Eight-inch staples are typically used in high velocity channel applications.
> 12 inches	Excessively loose soils, slopes containing fine silt, sand, or soft mud. Deep and soft fills, loose sands, silts, loams or "quick" conditions. Staples 12 inches and longer are used in shoreline applications in which wave action is a factor or in instances where soils remain saturated for long periods of time.

Site Preparation. The site shall be fine graded to a smooth profile and relatively free from all weeds, clods, stones, roots, sticks, rills, gullies, crusting and caking. Fill any voids and make sure that the channel is compacted properly.

Seeding. Seed may be applied prior or after the installation of the TRM. Select a native seed mix adapted to the local area and soil conditions. Choosing the appropriate seed mix will ensure optimum germination, root system development, vegetation density, and long term functionality. The types of seeds planted above the anticipated water line may differ from those below the anticipated water line. If the prepared seed bed becomes crusted or eroded, or if ruts or depressions exist for any reason prior to TRM installation, the contractor shall rework the soil until it is smooth and re-seed the reworked areas.

Seeding after TRM Installation.

- After installation of the TRM, apply seed.
- After seeding, spread and lightly rake ½-¾ inch of fine topsoil into the mat apertures to completely fill mat thickness. Use backside of rake or other flat implement.
- Spread topsoil using lightweight loader, backhoe, or other power equipment. Avoid sharp turns with equipment.
- Do not drive tracked or heavy equipment over mat. Avoid any traffic over matting if loose or wet soil conditions exist.
- Use shovels, rakes or brooms for fine grading and touch up.
- Smooth out soil filling, just exposing top netting of matrix.

TRM Installation in Channel Bottom. TRMs shall always be unrolled in the direction of water flow. First, install the TRM in the channel bottom. Try to minimize the number of seams that are placed on the bottom of the channel, as these are sites of weakness. Do not put seams in the center of the channel bottom or in areas of concentrated water flow. When installing two TRMs side by side in a waterway, the center of the TRM shall be centered in the area of concentrated water flow. Install adjoining TRMs away from the center of the channel bottom. Follow the manufacturer's recommendations for overlapping the TRM; generally the overlap will be 2-4 inches.

Secure the TRM at the beginning of the channel with a 6 inch x 6 inch check slot dug perpendicular to the direction of water flow across the entire width of the channel. Lay the TRM in the check slot with 30 inches extending upstream of the check slot. Stake or staple the TRM in the check slot on 12-inch centers. Backfill the anchor trench and compact the soil. Place seed over the compacted soil if necessary. Cover the compacted soil with the remaining 12 inches of the terminal end of the TRM. Staple or stake the terminal end of the TRM down slope of the anchor trench on 12-inch centers.

Check Slots. "Check slots" (cutoff trenches) must be provided every 25 to 50 feet to ensure water moving under the TRM is forced back to the surface. Longitudinal check slots are required to ensure off-site "side flows" do not get under the TRM. Similarly, beginning and terminal check slots are critical. Check slots can be installed in one of two ways, depending upon the Engineer's discretion and/or the manufacturer's recommendations.

One type of check slot is constructed by installing a double row of staples or stakes staggered and spaced 4 inches apart. The second option is to install a check slot 6 inches wide by 6 inches deep, and secure the TRM in the upstream side of the check slot with staples or stakes on 12-inch centers. Flip the TRM roll on the upstream edge. Back fill the check slot and compact the soil. Continue rolling the TRM downstream over the completed check slot.

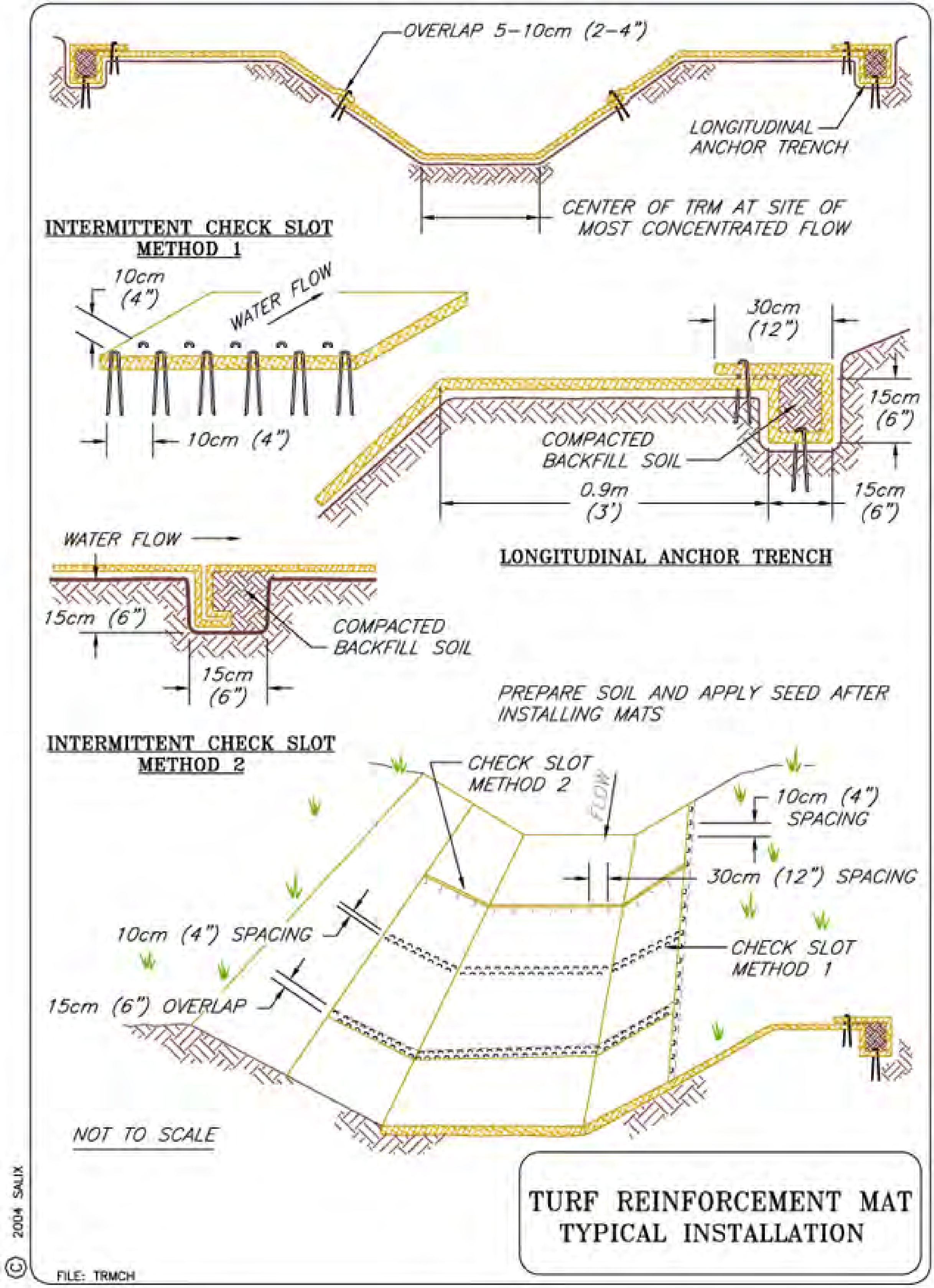
Installation on Side Slopes. As the TRM is installed from the channel bottom up the slope, a shingle-type installation is recommended with the up-slope TRM overlapping the lower TRM approximately 2-4 inches. Anchor the TRMs with a minimum of one staple every 24 inches across the width and one staple every 36 inches down the length. If the TRM needs to be spliced, "shingle" it as discussed above, with a 4-inch overlap. Use a staple check slot to secure the overlap. Anchor the TRM placed at the top of the channel slope in the same manner as described in the slope section.

Terminal End. Secure the TRM at the terminal end of the channel with a check slot similar to the one made at the beginning of the channel.

Alternative Channel Installation Method. Another installation method for TRMs is to install them vertically and approximately 3 feet onto the flat of the channel bottom. Construct a check slot in areas of concentrated water flow. Use a 2-4 inch shingle-type overlap upstream to downstream.

Monitoring/Maintenance: Basic monitoring consists of visual inspections to determine mat integrity and attachment performance. Rill development beneath the mat or edge lifting are evidence of inadequate attachment. Additional staking and trenching can be employed to correct defects. Recently placed mats may be replaced, but once vegetation becomes established, replacement is not a reasonable option.

Common Failures: Critical points in conveyance system applications where mats can lose support include points of overlap between mats, projected water surface boundaries and channel bottoms.


OVERLAP 5–10cm (2–4")
LONGITUDINAL ANCHOR TRENCH
CENTER OF TRM AT SITE OF MOST CONCENTRATED FLOW
INTERMITTENT CHECK SLOT METHOD 1
10cm (4")
WATER FLOW
10cm (4")
30cm (12")
15cm (6")
COMPACTED BACKFILL SOIL
0.9m (3')
15cm (6")
LONGITUDINAL ANCHOR TRENCH
WATER FLOW
15cm (6")
COMPACTED BACKFILL SOIL
15cm (6")
PREPARE SOIL AND APPLY SEED AFTER INSTALLING MATS
INTERMITTENT CHECK SLOT METHOD 2
CHECK SLOT METHOD 2
FLOW
10cm (4") SPACING
30cm (12") SPACING
10cm (4") SPACING
CHECK SLOT METHOD 1
15cm (6") OVERLAP
NOT TO SCALE
TURF REINFORCEMENT MAT TYPICAL INSTALLATION
© 2004 SALIX
FILE: TRMCH

TRENCH DRAIN – RC-6

Application: A trench drain is a gravel drain, construction with or without perforated pipe and filter fabric that is installed to intercept and divert shallow seepage away from the face of a streambank or divert surface runoff in a situation where a drainage swale or temporary diversion dike is not appropriate.

Design Guidelines: Trench drains should be considered when shallow, water bearing strata that conducts groundwater to emerge (daylights) at a streambank. A good example would be relatively permeable surface strata or water bearing sands up to 10 feet thick; for example, outwash sand or coarse alluvium overlying relatively impermeable silty clay deposits.

Materials/Equipment: Suitable drainage rock or gravel in addition to a perforated polymeric pipe. A small backhoe is required for excavating and backfilling the trench. A geotextile filter fabric will be required if the trench is to be lined.

Construction Specifications/Installation: A drainage trench is excavated parallel to and just behind the crest of a streambank or sensitive area. The bottom of the trench shall be keyed into an impermeable layer in the slope. The trench shall be backfilled with a coarse graded aggregate that meets filtration criteria; i.e., it shall allow unimpeded flow of groundwater while excluding fines from the seepage water. Alternatively, the trench can first be lined with a filter fabric (geotextile) that meets the filtration requirements and then be backfilled with a coarse aggregate. The purpose of the trench is to intercept and divert shallow seepage away from the face of the streambank/sensitive area. [Trench drains must connect to a surface discharge pipe or otherwise may be classified as a Class V Underground Injection (UIC) well requiring registration for rule authorization with DEQ.]

Trench Drains constructed without a pipe at the bottom are commonly known as French Drains (see Figure RC-6.1a). An efficient, well-constructed Trench Drain requires the use of perforated, jointed, slotted, or porous pipe placed near the bottom of a trench (see Figure RC-6.1b) that is surrounded with pea gravel or selected pervious filter aggregate. When a drain is excavated in erodible materials, synthetic filter fabrics (geotextiles) shall be used (see Figure RC-6.1c) to line the sides and bottom of the trench to prevent soil fines from entering the coarse backfill in the drain. The main backfill shall be specially selected pervious filter aggregate designed to allow unrestricted flow of water to the pipes.

Most drains should be equipped with pipes because gravel or rock-filled trenches have limited discharge capabilities even when clean aggregates are used. The discharge capabilities of drainage trenches backfilled with clean stone or coarse gravel, as estimated by Darcy's law, are given in Table RC-6.1. The required diameters of corrugated metal, concrete, and polymeric (smooth) drain pipes for a wide range of discharge quantities can be determined from the nomograph in Figure RC-6.2.

- The location of perforations and open joints in pipes shall always be placed to allow unobstructed flow to pipes.
- If a drainage pipe is completely surrounded with specially selected coarse filter aggregate (refer to Figure RC-6.1b), perforations can completely surround the pipe.

Trench drains shall discharge to stabilized areas or outlets only. Trench drains shall not discharge to steep slopes or disturbed/denuded areas. Instead, a stabilized conveyance system such as a slope drain (RC-1), stabilized diversion dike (RC-4), or a grass-lined channel (RC-5) shall be used to discharge flows to a stabilized area or outlet. Maximum trench depths are restricted to the reach of a backhoe/excavator or approximately 6-8 feet.

- Trench widths are also determined by the width of the excavator bucket, which can range from 12 to 24 inches.

- The water transmission characteristics of the drainage trench can be improved by placing a perforated or slotted drainage pipe on a slight grade at the bottom.
- The discharge from a trench drain shall be conveyed in a safe, non eroding manner down the slope directly to the stream.

Monitoring / Maintenance: Subsurface drains, including trench drains, are difficult to access and inspect once installed. A possible way to monitor the performance of a trench drain is to check the outflow from the pipe at the bottom of the interceptor trench. If there is steady shallow seepage towards a streambank, this exit pipe shall flow continuously. The effectiveness of a trench drain for intercepting shallow seepage can be monitored indirectly by examining for signs of seepage and/or slumping/sliding at the bank face.

Common Failures: The limitations of trench drains cited previously are the most common reasons for failure. Failure to excavate the trench deep enough to reach the impermeable base of a perched groundwater system may let ground water pass under the trench. Loss of drainage capacity from clogging of a drain can lead to the saturation and buildup of pore pressure in the streambank itself. Either of these conditions can lead to mass stability failure of a streambank or seepage induced erosion of the bank face.

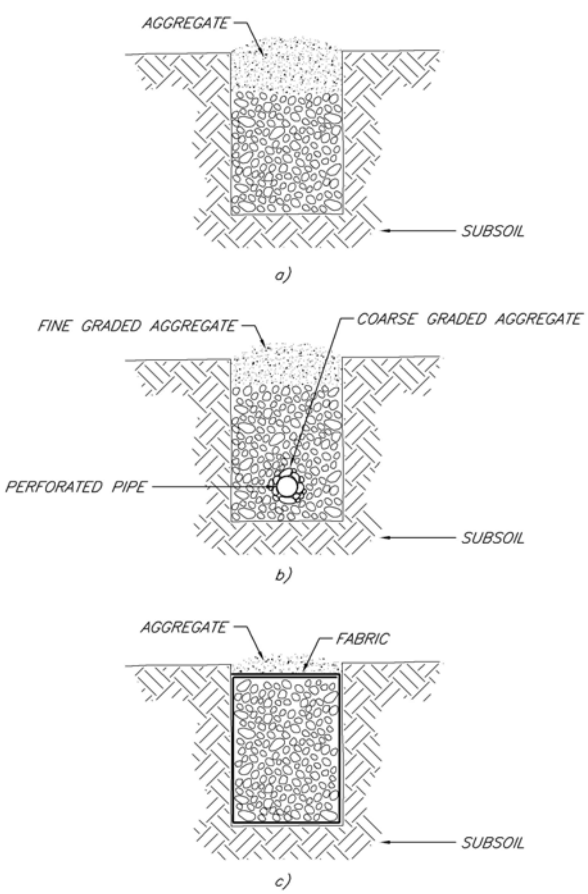


Figure RC-6.1. Cross sections of subsurface drains.
a) French drain,
b) Conventional trench drain with pipe,
c) Trench drain with filter fabric.

Size of stone	Permeability, ft/day	Slope	Capacity cu ft/day	Capacity gpm
$\frac{3}{4}$ to 1 in.	120,000	0.01	7200	38
$\frac{3}{4}$ to 1 in.	120,000	0.001	720	4
$\frac{3}{8}$ to $\frac{1}{2}$ in.	30,000	0.01	1800	9
$\frac{3}{8}$ to $\frac{1}{2}$ in.	30,000	0.001	180	1
$\frac{1}{4}$ to $\frac{3}{8}$ in.	6,000	0.01	360	2
$\frac{1}{4}$ to $\frac{3}{8}$ in.	6,000	0.001	36	0.2

Table RC-6.1. Discharge capacities of 3 x 2 feet cross sections of stone filled, trench drains.

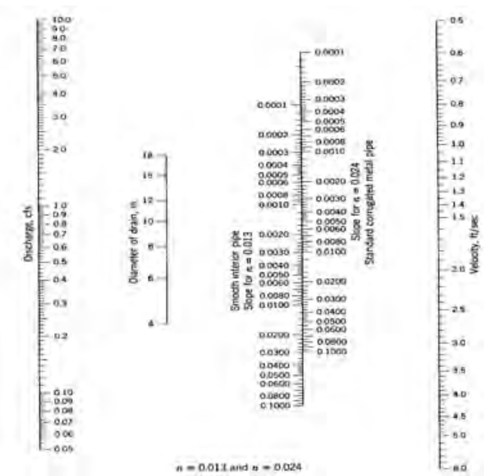


Figure RC-6.2. Nomograph for computing required size of circular drain, flowing full.

DROP INLET – RC-7

Application: Runoff passing over the top of slopes or embankments can trigger or expand gully erosion. Ponded water above the edge of a steep slope or bank can lead to slope failures through pressure, seepage, or infiltration into an unstable or denuded slope. A drop inlet is used to convey concentrated overbank runoff from the top to the toe of a slope. It is an L-shaped corrugated pipe that directs flow—usually originating from concentrated flow, or a drainage channel, ditch, or gully—through an earthen embankment. The pipe collects flow from the top of slope at the concentrated flow to a stabilized area at the toe of slope. The installation of drop inlets can reduce or eliminate gully erosion and downcutting at steep slopes.

Design Guidelines: Drop pipe structures are generally used with drainage channels or gullies deeper than 10 feet and embankments ranging from 15 to 20 feet high. Embankment slopes for drop inlets should range from 1H:1V to 3H:1V.

Materials/Equipment: Earthmoving equipment and erosion prevention measures are required for construction and stabilization of the embankment. Fill may need to be imported from offsite in addition to pipes, trash racks, and stone for construction.

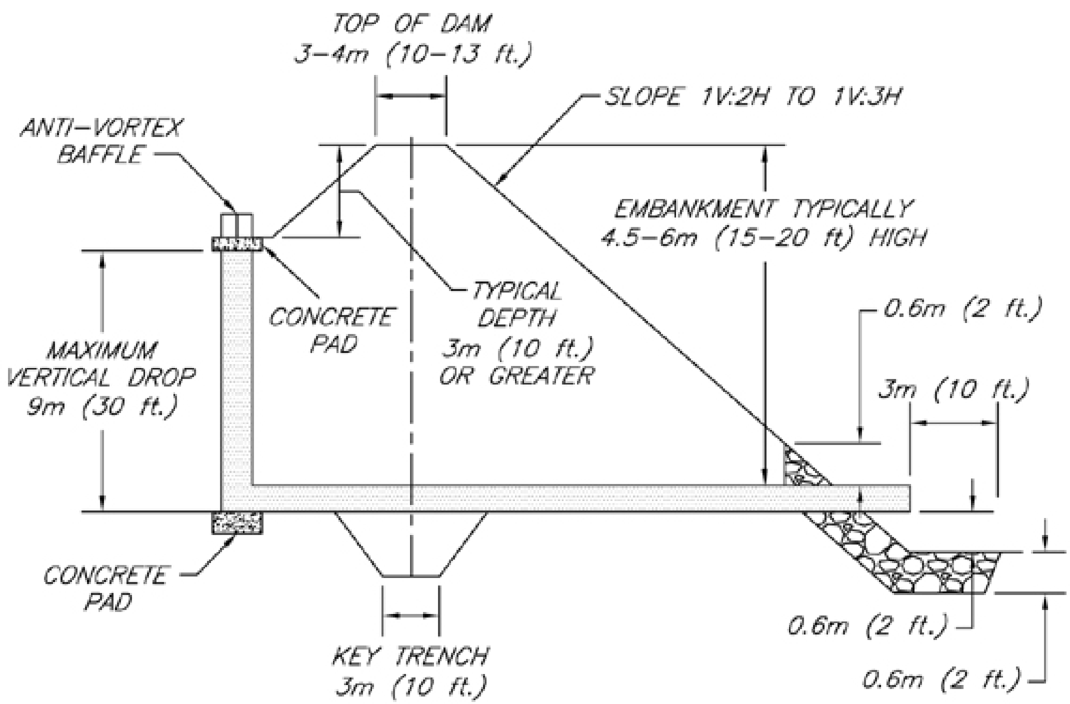
Construction Specifications/Installation:

- Pipes shall be sized to convey the 2- to 10-year storm event based on standard USDA Soil Conservation Service runoff curve number computations. An emergency spillway should be provided to convey flows larger than the design discharge. Drop inlets are designed for discharges less than 200 ft^3/sec, with a vertical distance from the inlet weir crest to the outlet pipe invert less than 30 feet. The pipe diameter and length are used to compute head-discharge relations, but allowing for the pipe diameter to be adjusted to avoid orifice flow at discharges less than or equal to design flow.
- Proper compaction of the dike (RC-4), berm, or dam at the inlet is necessary for integrity of the structure and to allow for ponding without seepage.
- Drop pipes may be designated non-storage structures, which are sized to pass the 2- to 5-year event, or as temporary storage structures, which are designed to impound runoff from the 25-year event. Water retention is governed by site factors (e.g., soils, topography, and water supply) and by the elevation of the inlet weir and emergency spillway.
- Pipe materials can be either aluminized or galvanized polymer-coated metal or polymeric materials. To prevent seepage through the earthen embankment seepage collars for structures with conduits less than 4 feet in diameter and with annular filter drainage rings for conduits greater than 4 feet.
- When the structure is designed to impound water permanently, a filter drainage diaphragm shall be used, concrete pads shall be provided at the top and bottom of the vertical pipe, and an anti-vortex baffle shall be placed in the inlet to maintain weir flow and avoid vibration during large events. Outlets are supported with grouted riprap and secured with screw anchors. In addition, stone erosion protection shall be provided at the outlet for structures greater than 4 feet in diameter.
- Ensure the inlet pipe is higher than the ponding height at the inlet.
- Check dams (RC-11) may be required in the drainage channel prior to the inlet of the structure to reduce velocities and prevent gully erosion and sediment transport.
- Inlet protection may be required at the inlet structure to prevent sediment transport through the structure.

Monitoring/Maintenance: Routine inspections are required to ensure the structure is working correctly. Maintenance is required to prevent clogging at the entrance of the structure or trash rack for removal of sediment accumulations in the ponded area at the base of the inlet structure, and to maintain inlet protection. The upstream drainage channel shall be inspected for gully erosion and maintenance of the check dams. If the residence time in the ponded area at the inlet structure is not long enough, a taller inlet pipe may be necessary to allow for more settling of sediments.

Common Failures:

- Clogging of the down-pipe leading to overtopping of the containment dike and erosion of the downstream face of the structure embankment.
- Uncontrolled sediment loading from the upstream drainage channel runoff conveyed through the structure to the receiving stream, channel, or designated discharge point.
- Sediment discharges from the ponded area around the structure's inlet because of maintained inlet protection (SC-8) at the inlet structure.
- Too short of an inlet structure causing too short of a residence time in the ponded area prior to discharge to the inlet.



DROP INLET

FILE: DI

IN-STREAM DIVERSION TECHNIQUES – RC-9

Application: A stream diversion is a temporary bypass through a pipe, flume, or excavated channel that carries water flow around in-stream work areas. Stream diversions are commonly used during culvert installations or replacements. Where possible, a stream diversion should be the first choice to control erosion and sediment during the construction of culverts or other in-stream structures. During construction in a watercourse, particularly for culvert installation and repair, these temporary water bypass structures are an effective sediment and erosion control technique.

Design Guidelines: The selection of which in-stream diversion technique to use will depend upon the type of work involved, physical characteristics of the site, and the volume of water flowing through the project.

Advantages	Disadvantages
Pumped Diversion	
• Downstream sediment transport can almost be eliminated • De-watering of the work area is possible • Pipes can be moved about to accommodate construction operations • The dams can serve as temporary access • Increased flows can be managed by adding more pumping capacity	• Flow volume is limited by pump capacity • Requires 24-hour monitoring of pumps • Sudden rain could overtop dams • Minor in-stream disturbance to install and remove dams
Excavated Channels and Flumes	
• Isolates work from water flow and allows dewatering • Can handle larger flows than pumps	• Bypass channel or flume must be sized to handle flows, including possible floods • Channels require stabilization • Flow diversion and then re-direction with small dams causes in-stream disturbance and sediment

In-stream diversions shall not be used without identifying potential impacts to the stream channel, or until all necessary permits have been obtained. Check with federal and state regulatory authorities (e.g., U.S. Army Corps of Engineers, Oregon Division of State Lands, Oregon Department of Fish and Wildlife, NOAA Fisheries) for permitting and design requirements. Some issues that need to be addressed include removal/fill, in-water work period, fish passage, intake screening, water quality, and site restoration.

Materials/Equipment: Primary and backup pumps, culvert material, intake screen, check dam materials.

Construction Specifications/Installation:

- The pumped diversion is suitable for intermittent and low flow streams that can be pumped. Pump capacity must be sufficient for design flow. The upper limit is about 10 ft^3/sec, the capacity of two 8-inch pumps.
- A temporary dam is constructed upstream and downstream of the work area and water is pumped through the construction project in pipes. Dam materials shall be selected to be erosion resistant, such as steel plate, sheet pile, sandbags, continuous berms, inflatable water bladders, etc.

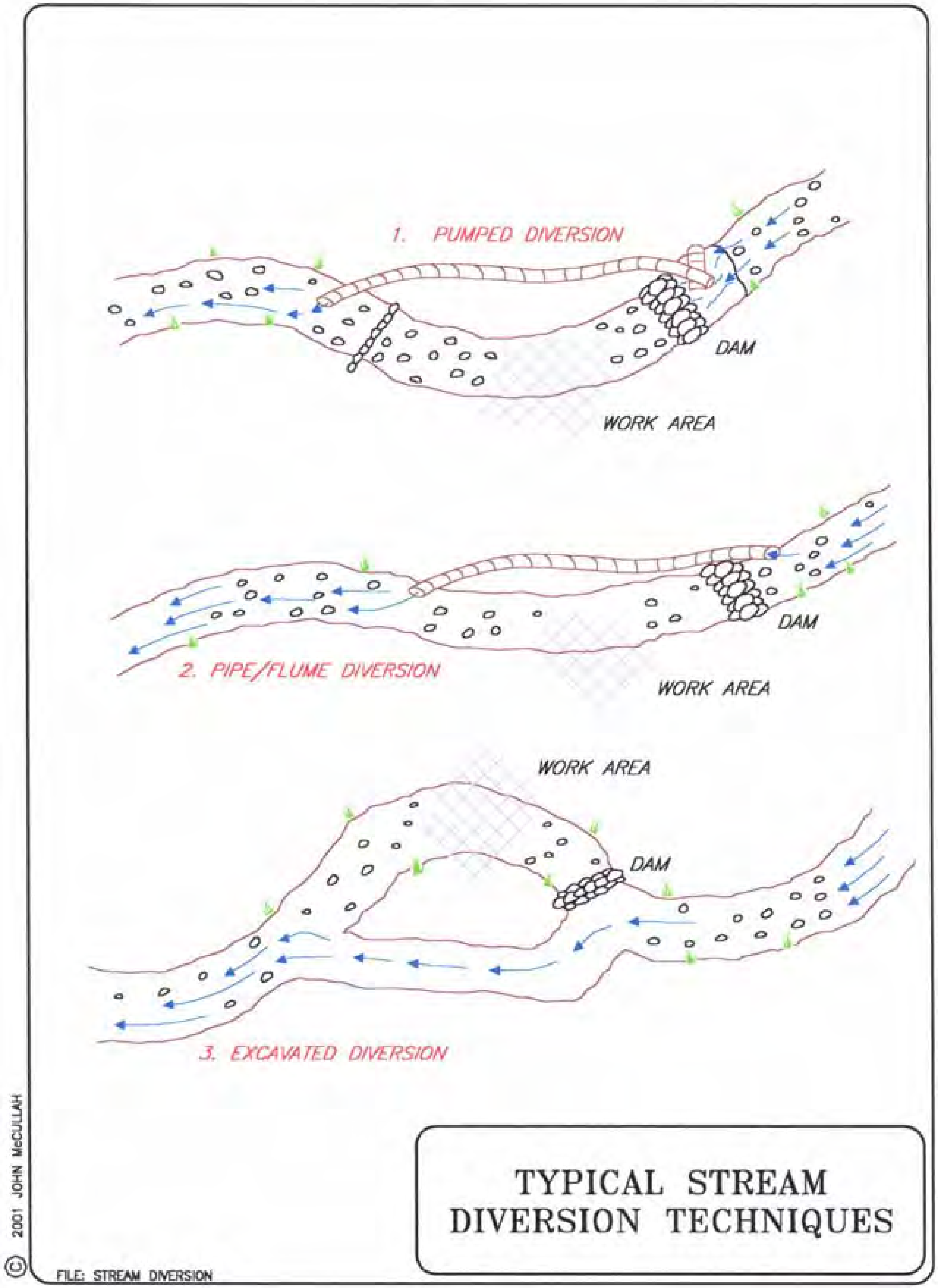
- A temporary bypass channel can also be constructed by excavating a temporary channel or passing the flow through a heavy pipe (called a flume), and excavating a trench under it. Typical stream sizes are less than 20 feet wide and less than 100 ft^3/sec.

Monitoring / Maintenance:

- All stream diversions must be closely maintained and monitored.
- Pumped diversions require 24-hour monitoring of pumps.
- Upon completion of the work performed, the stream diversion shall be removed and flow shall be re-directed through the new culvert or back into the original stream channel.

Common Failures:

- Insufficient pump capacity.
- No contingency pump on site.


1. PUMPED DIVERSION
DAM
WORK AREA
2. PIPE/FLUME DIVERSION
DAM
WORK AREA
WORK AREA
DAM
3. EXCAVATED DIVERSION
TYPICAL STREAM
DIVERSION TECHNIQUES
© 2001 JOHN McCULLAH
FILE: STREAM DIVERSION

IN-STREAM ISOLATION TECHNIQUES – RC-10

Application: An in-stream isolation technique is a temporary structure built into a waterway to enclose a construction area and reduce sediment pollution from construction work in or adjacent to water. During construction in a watercourse, these structures are designed to reduce turbidity and sediment discharge.

Design Guidelines: Isolation structures may be used in construction activities such as streambank stabilization, culvert installation, bridges, piers or abutments. They may be used in combination with other methods such as clean water bypasses and/or pumps.

This technique shall not be used:

- If there is insufficient streamflow to support aquatic species.
- In deep water unless designed or reviewed by a professional engineer.
- To completely dam streamflows.

Materials/Equipment: The structures may be made of rock, sand bags, wood or water-filled geotextiles (aqua barriers). Materials for isolation structures shall be selected based on ease of maintenance and complete removal following construction activities.

Construction Specifications/Installation:

Construction specifications shall be site specific. See notes on details. When used in watercourses or streams, isolation structures must be used in accordance with applicable federal and state regulations administered by the U.S. Army Corps of Engineers and Oregon Division of State Lands. Issues to be addressed include in-water work periods, fish salvage requirements, fish passage regulations, and turbidity thresholds.

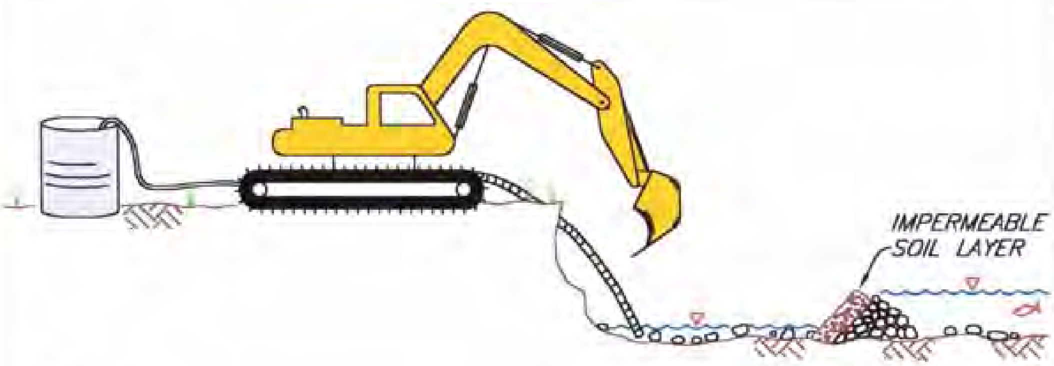
Monitoring/Maintenance:

- During construction, inspect daily.
- Schedule additional inspections during storm events.
- Immediately repair any gaps, holes or scour.
- Remove sediment buildup.
- Upon construction completion, remove structure. Recycle or re-use if applicable.
- Revegetate areas disturbed by removal of berm or cofferdam as required.

Common Failures:

- Wetland removal/fill permit requirements.
- Lack of fish handling permit from NOAA Fisheries/Oregon Department of Fish and Wildlife.
- Restrictions to avoid harm of endangered and threatened fish species.
- Insufficient pump capacity.
- Restrictions on pile driving.

BENEFITS/LIMITATIONS
- Allows partial dewatering
- Relatively inexpensive
- Useful for small streams
- Minimal TSS when removed



NOTES:

Step 1. Install clean gravel

Step 2. Place impermeable soil

Step 3. Do work

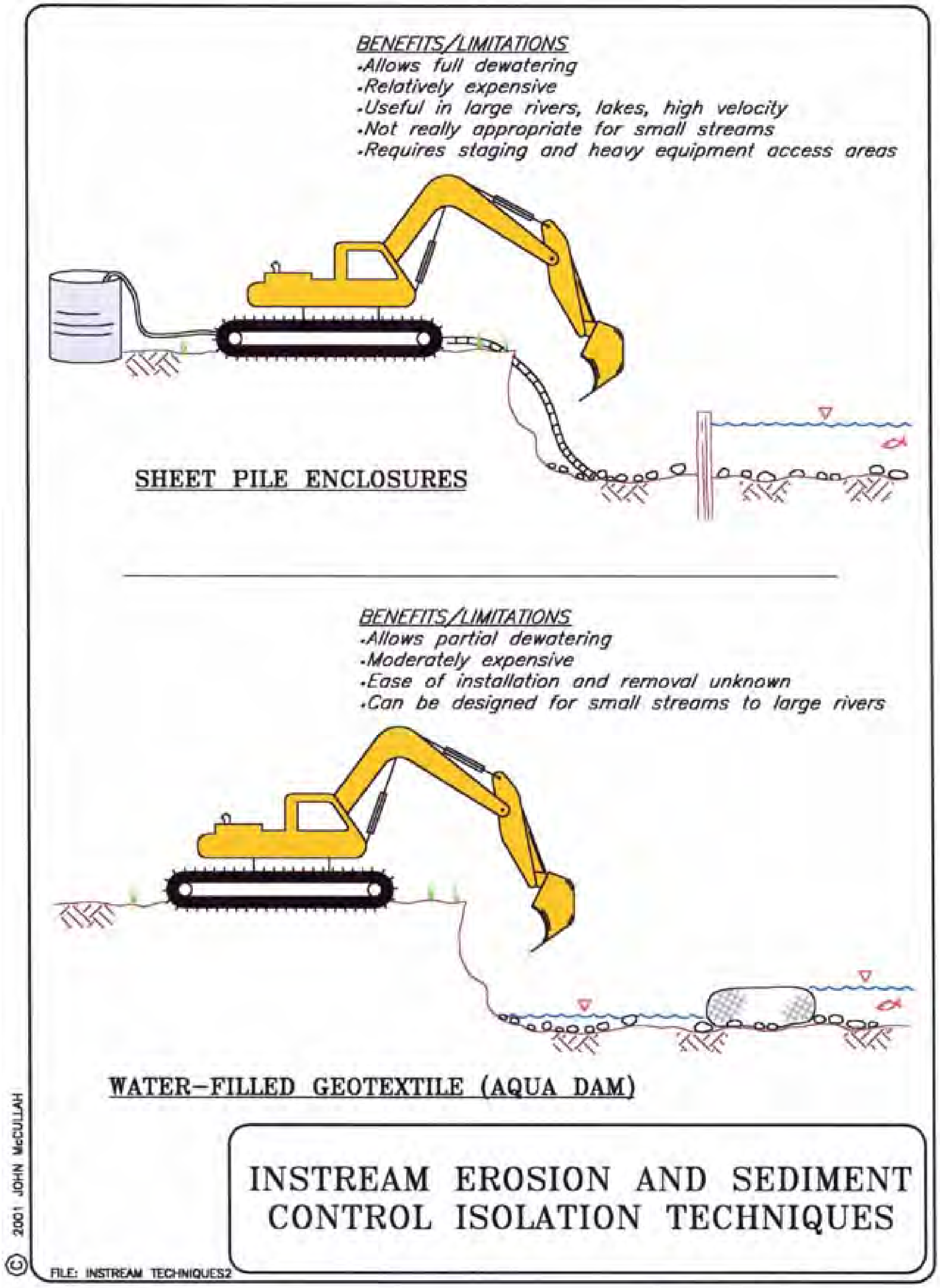
Step 4. Decommission berm by removing soil layer first

Step 5. Pump work area. Head differential will cause turbid water to flow into work area through gravel

Step 6. Remove or spread gravel

GRAVEL/SOIL BERM INSTREAM ISOLATION TECHNIQUE

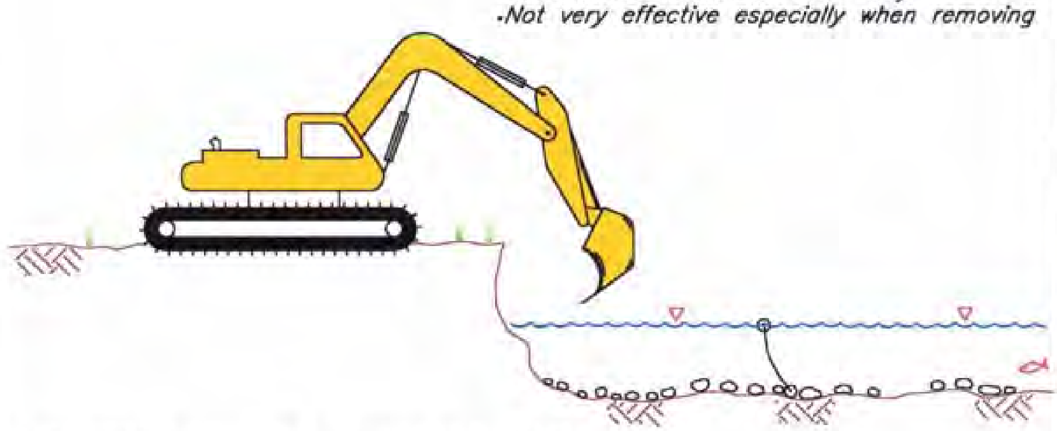
FILE: BERM INSTREAM TECHNIQUES


BENEFITS/LIMITATIONS
•Allows full dewatering
•Relatively expensive
•Useful in large rivers, lakes, high velocity
•Not really appropriate for small streams
•Requires staging and heavy equipment access areas
SHEET PILE ENCLOSURES
BENEFITS/LIMITATIONS
•Allows partial dewatering
•Moderately expensive
•Ease of installation and removal unknown
•Can be designed for small streams to large rivers
WATER-FILLED GEOTEXTILE (AQUA DAM)
INSTREAM EROSION AND SEDIMENT CONTROL ISOLATION TECHNIQUES
© 2001 JOHN McCULLAH
FILE: INSTREAM TECHNIQUES2

BENEFITS/LIMITATIONS
- *Allows partial dewatering*
- *Many different types available*
- *Relatively expensive*
- *Can be designed for large and small streams*
- *Ease of installation and removal unknown*

COFFER DAMS

BENEFITS/LIMITATIONS
- *Does not allow dewatering*
- *Inexpensive*
- *Used in slow water or lakes only*
- *Not very effective especially when removing*



GEOTEXTILES, SILT BARRIERS, CURTAINS

INSTREAM EROSION AND SEDIMENT CONTROL ISOLATION TECHNIQUES

FILE: INSTREAM TECHNIQUES1

CHECK DAMS – RC-11

Application: A check dam is a small, temporary dam placed across a natural or man-made channel or drainage ditch. Check dams reduce drainage ditch erosion caused by storm water runoff, by restricting the velocity of flow in the ditch. Check dams are often used as a temporary measure while a channel is being permanently lined with vegetation or other materials to prevent erosion.

Design Guidelines: Check dams shall be placed at a distance and height to allow small pools to form behind them. The maximum spacing between the dams shall be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam.

Materials/Equipment: Check dams can be constructed of rocks, logs, timbers, or gravel-filled bags. If gravel-filled bags:

Bag Material. Bags shall be either polypropylene, polyethylene or polyamide woven fabric, minimum unit weight four ounces per square yard, mullen burst strength exceeding 300 psi in conformance with the requirements in ASTM designation D3786, and ultraviolet stability exceeding 70% in conformance with the requirements in ASTM designation D4355.

Bag Size. Each gravel-filled bag shall have a length of 18 inches, width of 12 inches, thickness of 3 inches, and mass of approximately 33 lbs. Bag dimensions are nominal, and may vary based on locally available materials. Alternative bag sizes shall be submitted to the engineer for approval prior to deployment.

Fill Material. Fill material shall be between 0.4 and 0.8 inches in diameter, and shall be clean and free from clay balls, organic matter, and other deleterious materials. The opening of gravel-filled bags shall be secured such that gravel does not escape. Gravel-filled bags shall be between 28 and 48 lbs in mass. Fill material is subject to approval by the engineer.

Construction Specifications/Installation:

- High flows (typically a 2-year storm or larger) shall safely flow over the check dam without an increase in upstream flooding or damage to the check dam.
- Where grass is used to line ditches, check dams shall be removed when grass has matured sufficiently to protect the ditch or swale.
- Construct rock dams such that structures are not damaged by vehicles and do not impede travel ways.
- Rock dams shall be constructed of 2-15 inch rock.
- Keep the center rock (spillway) section at least 6 inches lower than the outer edges.
- Extend the abutments 18 inches into the channel bank.
- Gravel bags or biobags may only be used as check dams with the following specifications:
  - Install along a level contour.
  - Tightly abut bags and stack bags using a pyramid approach. Bags shall not be stacked any higher than 3 feet.
  - Upper rows of bags shall overlap joints in lower rows.
- Local and state requirements shall be met concerning fencing and signs warning the public of hazards of soft sediment and floodwater.

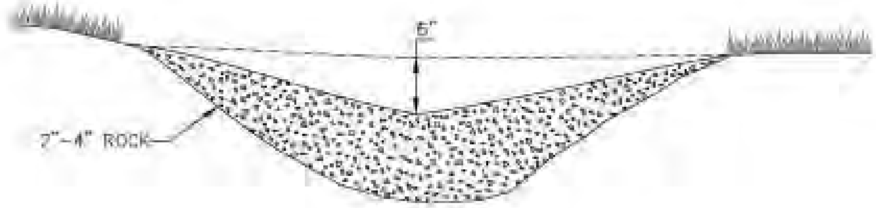
Monitoring/Maintenance:

- Inspect check dams before, during, and after each rainfall event. Repair damage as needed.
- Remove sediment when depth reaches one-third the height of the check dam .
- Remove accumulated sediment prior to permanent seeding or soil stabilization.
- Remove check dam and accumulated sediment when check dams are no longer needed.

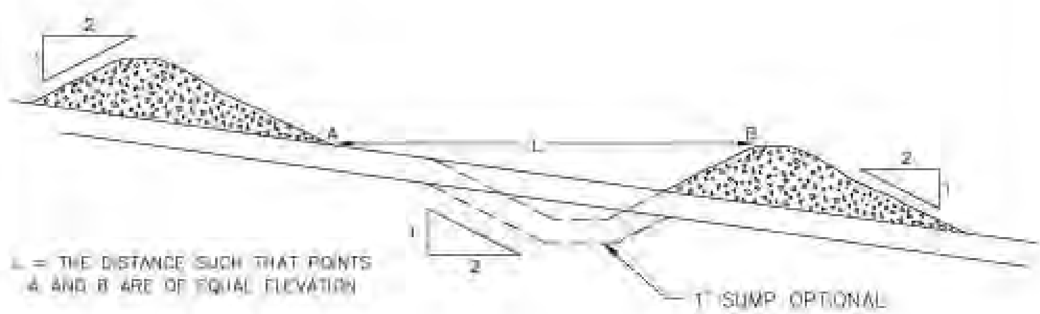
- Removed sediment shall be incorporated in the project or disposed of properly.

Common Failures:

- Insufficient ballast in dam to resist blowout.
- Side-cutting if not keyed into slopes.
- Bags can degrade over time.

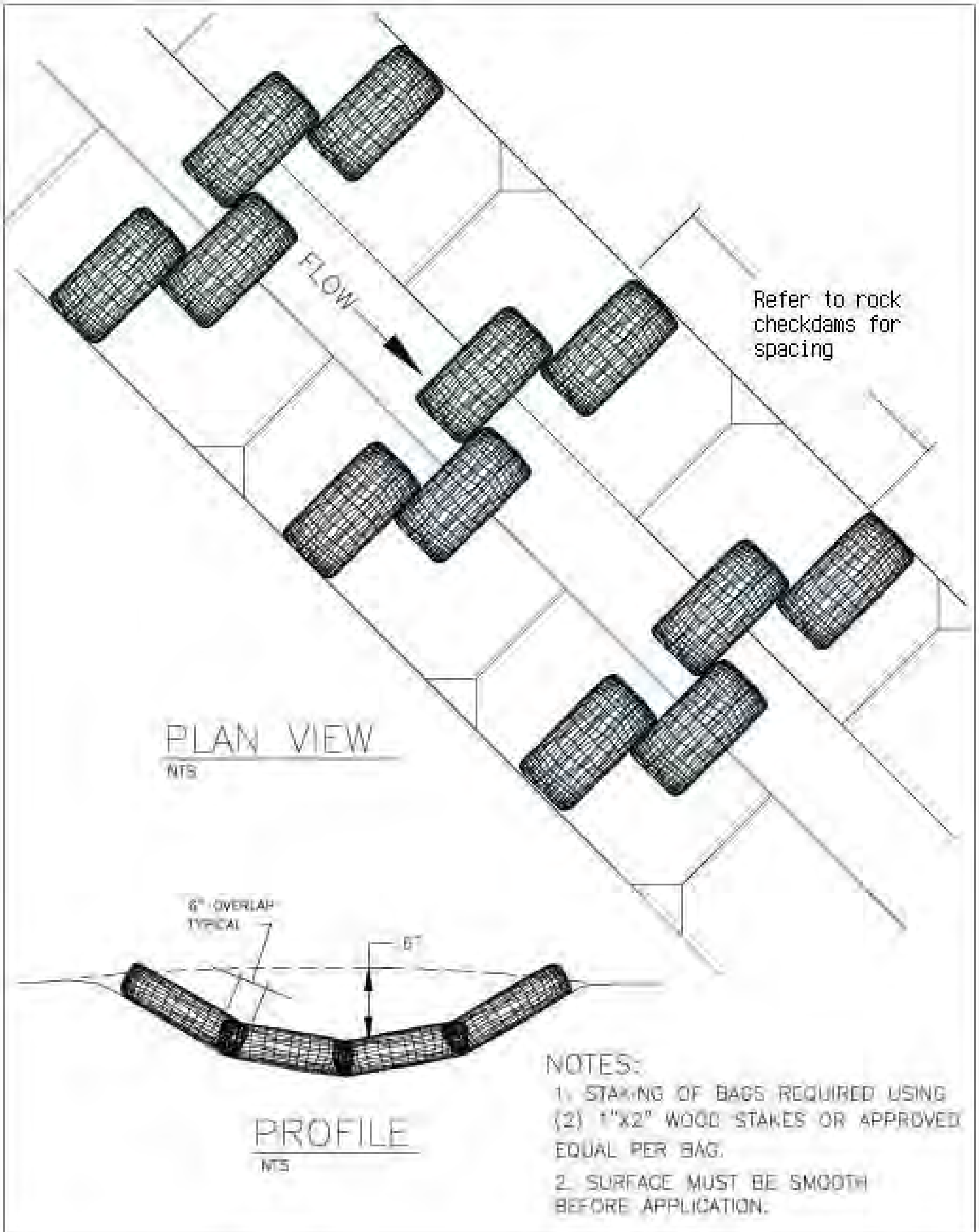


ROCK CHECK DAM



SPACING BETWEEN CHECK DAMS

CHECK DAM ROCK	RC-11



CHECK DAM
BIO FILTER BAG

RC-11

EPSC Details For Sediment Control

SEDIMENT FENCE – SC-1

Application: A linear barrier and perimeter control is designed for sheet flow, not concentrated flow. It is used as a temporary measure that intercepts sediment-laden runoff and filters or traps sediment or non-stormwater flows behind the barrier. It should not be placed across stream channels.

Design Guidelines: A last line of defense before stormwater leaves the site, and must be carefully selected, properly installed, and diligently maintained. The contributory drainage area shall not exceed 100 square feet per lineal foot of fence.

Materials/Equipment: Prefabricated fence fabric shall consist of material approved by its manufacturer for use in sediment fence applications and shall include pre-fabricated pockets for stake installation. Select standard duty or heavy duty prefabricated sediment fence based on criteria described below.

Construction Specifications/Installation:

- Standard or heavy duty sediment fence shall have manufactured stitched loops with 2-inch x 2-inch x 4-foot posts. Stitched loops shall be installed on the uphill side of the slope.
- Sediment fence shall be installed a minimum of 3 feet from the toe of a slope to maximize storage.
- A trench shall be excavated deep enough so that 6 inches of the fabric is buried along the line of the posts.
- The trench shall be backfilled with soil and compacted on both sides of the sediment fence.
- When a sediment fence must be overlapped, join the two end stakes by wrapping them in at least one and a half turns of fabric and driving the joined stakes into the ground together.
- At the end point of a sediment fence, angle the fence slightly uphill for one full 6-foot panel.
- Sediment fence shall be installed along contours at intervals noted in Table SC-1.1 below.

TABLE SC-1.1. SEDIMENT BARRIER SPACING

Percent Slope	Slope	Maximum Spacing
<20	Less than 5H:1V	100 feet
20 to 30	5H:1V to 3H:1V	50 feet
> 30	Greater than 3H:1V	25 feet

Standard Duty Prefabricated Sediment Fence

- Slope of area draining to fence is 4H:1V or less.
- Use is limited to less than 5 months.
- Area draining to fence produces moderate sediment loads.
- Layout and install in accordance with attached BMP detail.

Heavy Duty Prefabricated Sediment Fence

- Slope of area draining to fence is 1H:1V or less.
- Use is limited to 8 months. Longer periods may require fabric replacement.
- Area draining to fence produces moderate sediment loads.

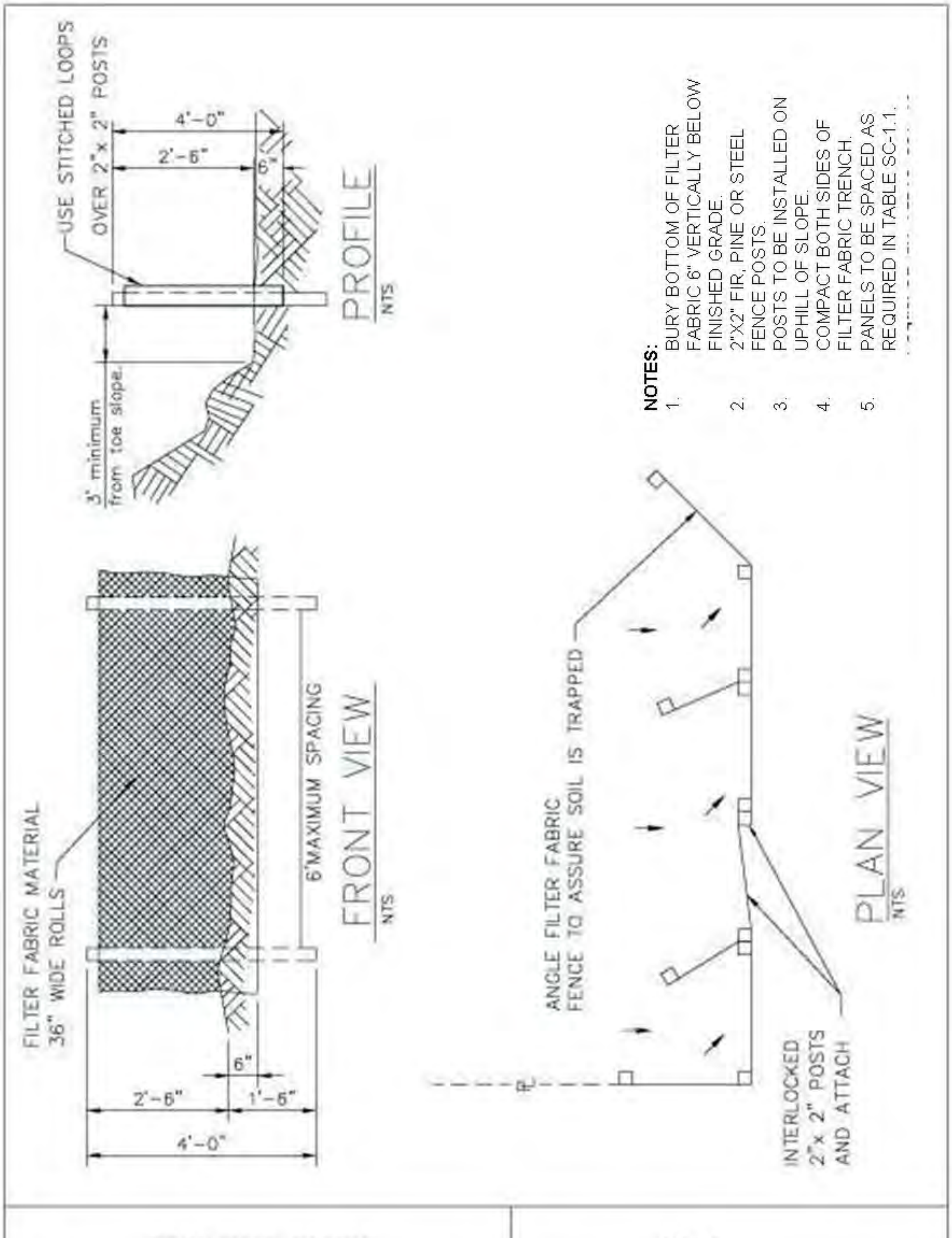
- Heavy duty sediment fences typically have the following physical characteristics:
  - Fence fabric has greater tensile strength and permittivity than other available fabric types, and may be reinforced with a backing or additional support to increase fabric strength.
  - Posts are spaced closer together than other available pre-manufactured sediment fence types.
- Layout and install in accordance with attached typical layout and BMP detail.
- Except for the fence ends, the difference in elevation between the highest and lowest point along the top of the sediment fence shall not exceed one-third the fence height.

Monitoring / Maintenance:

- Repair undercut sediment fences.
- Repair or replace split, torn, slumping, or weathered fabric.
- Inspect sediment fence before, during, and after storm events.
- Any required repairs shall be performed as soon as possible and before any predicted storm events
- Remove sediment when accumulation reaches 1/3 the fence height.
- The removed sediment shall be incorporated in the project, disposed of properly, or appropriately stabilized with vegetation.
- Remove sediment fence when it is no longer needed and when the upslope area has been stabilized. Fill and compact post holes and anchorage trench, remove sediment accumulation, and grade fence alignment to blend with adjacent ground.

Common Failures:

- Improper installation.
- Poor maintenance—sediment shall be removed when accumulation reaches 1/3 of the fence height.



SEDIMENT FENCE	SC-1

SAND BAG BARRIER – SC-2

Application: Linear barrier and perimeter control. Sand bag barriers are designed for sheet flow, not concentrated flow, and must never be placed across a stream or channel. A temporary measure that intercepts sediment-laden runoff and filters or traps sediment or non-stormwater flows behind the barrier.

Design Guidelines: Sand bags are much less permeable than gravel bag berms and are appropriate when used to block and contain non-stormwater flows (e.g., discharges from concrete saw cutting), but can result in flooding when used to control stormwater flows. Topography and drainage patterns are important considerations in the design of the linear barriers. Barriers shall be placed on the same contour, and it is important that barriers be properly installed and keyed into the soil to prevent undermining (i.e. flow passing under the barrier). Sand bag barriers are intended to block and divert flow. They are not intended to be used as filtration devices. As a last line of defense before storm water leaves the site, they must be carefully selected, properly installed, and diligently maintained.

Materials/Equipment:

- **Bag material.** Sand bag shall be polypropylene, polyethylene or polyamide woven fabric, minimum unit weight 4 ounces per square yard, mullen burst strength exceeding 300 psi in conformance with the requirements in ASTM designation D3786, and ultraviolet stability exceeding 70% in conformance with the requirements in ASTM designation D4355. Use of burlap is not acceptable.
- **Bag size.** Each sand-filled bag shall have a length of 18 inches, width of 12 inches, thickness of 3 inches, and mass of approximately 33 lbs. Bag dimensions are nominal, and may vary based on locally available materials. Alternative bag sizes shall be submitted to the engineer for approval prior to deployment.
- **Fill material.** All sand bag fill material shall be non-cohesive, Class 1 or Class 2 permeable material free from clay and deleterious material. Fill material is subject to approval by the engineer.

Construction Specifications/Installation:

- Install along a level contour.
- Turn ends of sand bag row up slope to prevent flow around the ends.
- Sand bag barriers shall be used in conjunction with temporary soil stabilization controls up slope to provide effective erosion and sediment control.
- Construct sand bag barriers with a set-back of at least 3 feet from the toe of a slope. Where it is determined to be not practical due to specific site conditions, the sand bag barrier may be constructed at the toe of the slope, but shall be constructed as far from the toe of the slope as practicable.
- Sand bag barriers, as well as other sediment barriers, shall be installed on the contour at intervals noted in Sediment Fence BMP, Table SC-1.1.
- Sand bag barriers can be used as a diversion technique, see Temporary Diversion Swale (RC-3).

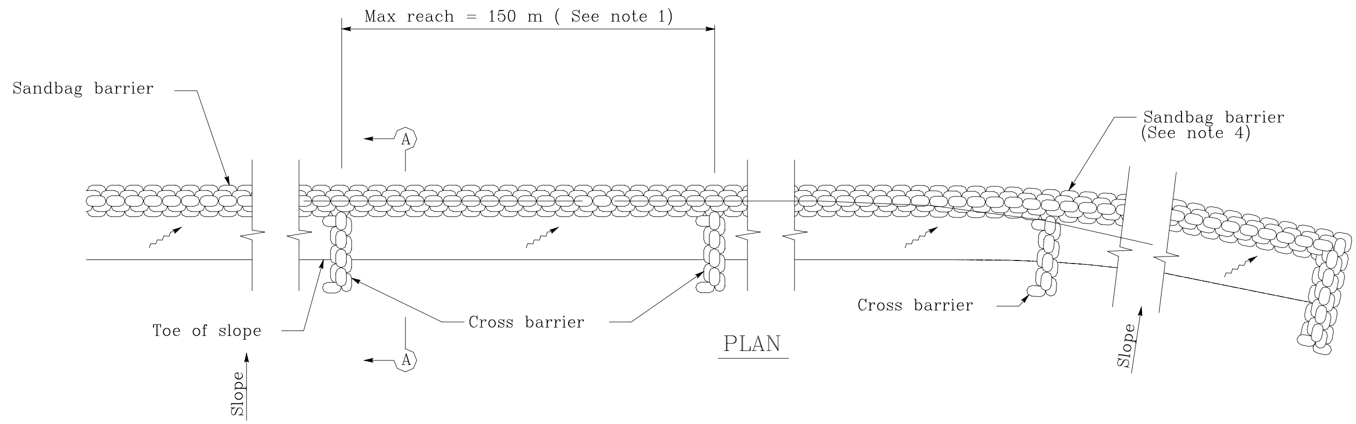
Monitoring/Maintenance:

- Inspect barriers before, during, and after each rainfall event, and weekly throughout the rainy season.

- Reshape or replace sand bags, as needed.
- Repair washouts or other damages, as needed.
- Inspect sand bag barriers for sediment accumulations and remove sediment when accumulation reaches 1/3 the barrier height. Removed sediment shall be incorporated in the project at locations designated by the engineer or shall be disposed of properly.
- Remove sand bags when no longer needed. Remove sediment accumulation, and clean, re-grade, and stabilized the area.

Common Failures:

- Sand bags not placed along contour.
- Sand bags may degrade over time.



TEMPORARY LINEAR SEDIMENT BARRIER (TYPE SANDBAG)

STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

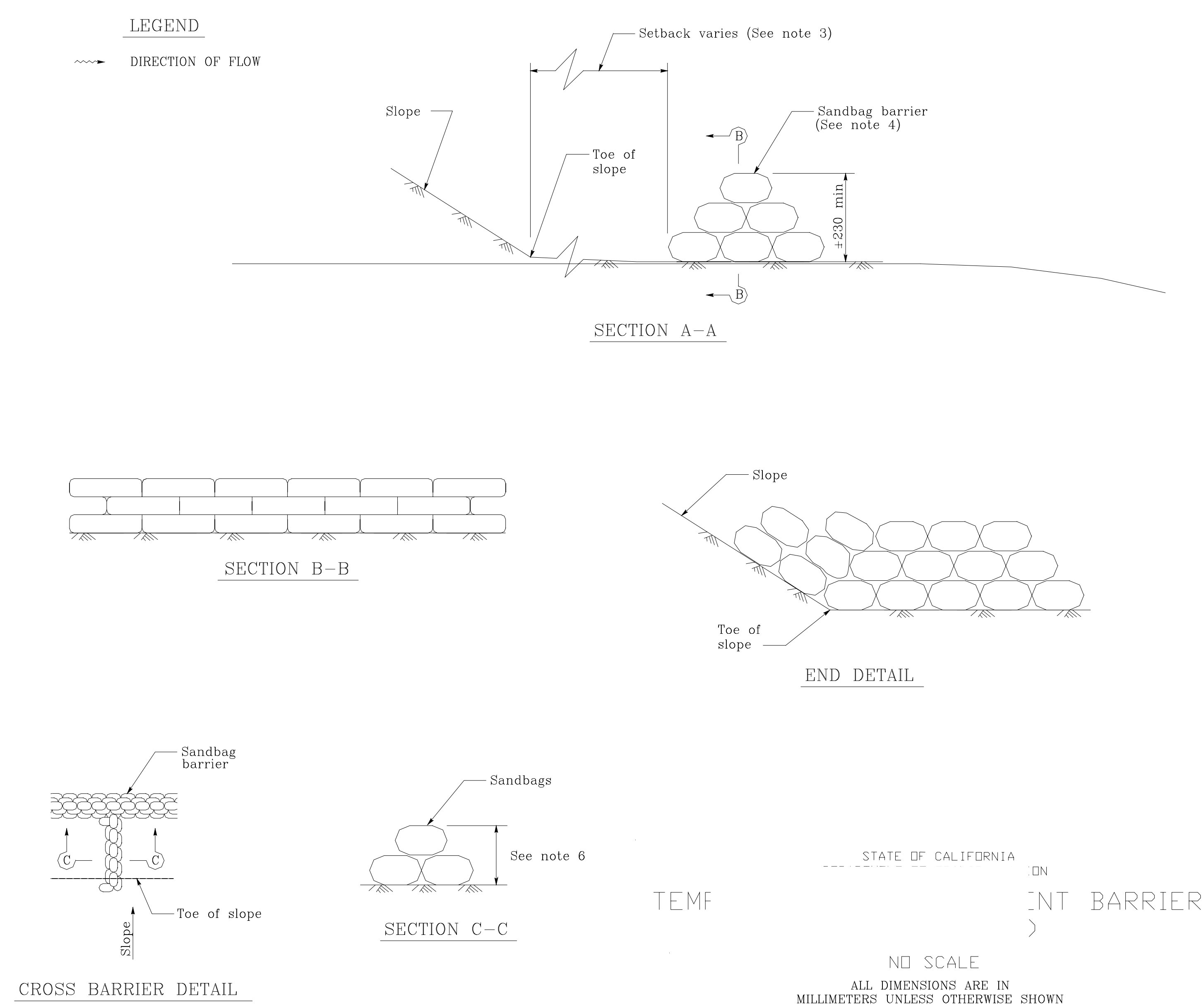
TEMPORARY LINEAR SEDIMENT BARRIER (TYPE SANDBAG)

NO SCALE

ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SHOWN

NOTES

1. Construct the length of each reach so that the change in base elevation along the reach does not exceed 1/2 the height of the linear barrier. In no case shall the reach length exceed 150 m.
2. Place sandbags tightly.
3. Dimension may vary to fit field condition.
4. Sandbag barrier shall be a minimum of 3 bags high.
5. The end of the barrier shall be turned up slope.
6. Cross barriers shall be a min of 1/2 and a max of 2/3 the height of the linear barrier.
7. Sandbag rows and layers shall be staggered to eliminate gaps.


LEGEND
DIRECTION OF FLOW
Setback varies (See note 3)
Slope
Toe of slope
Sandbag barrier (See note 4)
±230 min
B
B
SECTION A-A
SECTION B-B
Slope
Toe of slope
END DETAIL
Sandbag barrier
C
C
Toe of slope
Slope
CROSS BARRIER DETAIL
Sandbags
See note 6
SECTION C-C
STATE OF CALIFORNIA
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NO SCALE
ALL DIMENSIONS ARE IN
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GRAVEL BAG BERM – SC-3

Application: A linear barrier and perimeter control. A temporary measure that intercepts sediment-laden runoff and filters or traps sediment or non-stormwater flows behind the barrier.

Gravel bag berms and other devices that allow filtration should be used for sediment control applications where the goal is to slow water and promote ponding behind the barrier but still allow flow through the device to discharge with a reduced flooding potential.

Design Guidelines: It is important to select the correct BMP for the intended application, particularly for the use of gravel bag berms versus sand bags. Gravel bag berms are intended to be used as filtration devices. Similar applications are check dams (RC-11), Type 4 inlet protection (SC-8), and sediment fences
(SC-1) because all retain sediment and release water. On the contrary, sand bag barriers (SC-2) block and divert flow, similar to a temporary diversion swale (RC-3). Gravel bag berms are much more permeable than sand bags and are less likely to result in flooding when used to control stormwater flows.

These barriers are designed for sheet flow, not concentrated flow, and must never be placed across a stream or channel. Therefore, the topography and drainage patterns are important considerations in the design when they are used as linear barriers. Barriers shall be placed along a contour, and it is important that barriers be properly installed and keyed into the ground to prevent undermining (i.e., flow passing under the barrier). As a last line of defense before stormwater leaves the site, they must be carefully selected, properly installed, and diligently maintained.

Materials/Equipment:

- **Bag material.** Bags shall be woven polypropylene, polyethylene or polyamide fabric, minimum unit weight 4 ounces per square yard, mullen burst strength exceeding 300 psi in conformance with the requirements in ASTM designation D3786, and ultraviolet stability exceeding 70% in conformance with the requirements in ASTM designation D4355.
- **Bag size.** Each gravel-filled bag shall have a length of 18 inches, width of 12 inches, thickness of 3 inches, and mass of approximately 33 lbs. Bag dimensions are nominal, and may vary based on locally available materials. Alternative bag sizes shall be submitted to the engineer for approval prior to deployment.
- **Fill material.** Gravel shall be between 0.4 and 0.8 inch in diameter, and shall be clean and free from clay balls, organic matter, and other deleterious materials. The opening of gravel-filled bags shall be between 28 and 48 lbs in mass. Fill material is subject to approval by the engineer.
- A certificate of compliance for the gravel and bags shall be provided.

Construction Specifications/Installation:

- When used as a linear control for sediment removal:
  - Install along a level contour.
  - Turn ends of gravel bag row up slope to prevent flow around the ends.
  - Generally, gravel bag berms shall be used in conjunction with temporary soil stabilization controls up slope to provide effective erosion and sediment control.
  - Gravel bag barriers as well as other sediment barriers shall be installed at the contour intervals noted in the Sediment Fence BMP, Table SC-1.1.
- When used for concentrated flows:
  - Stack gravel bags to required height using a pyramid approach.

- Upper rows of gravel bags shall overlap joints in lower rows.

- Construct gravel bag barriers with a set-back of at least 3 feet from the toe of a slope. Where constrained due to specific-site conditions, the gravel bag barrier shall be constructed at the toe of the slope, but as far from the toe of the slope as practicable.
- See Sand Bag Barrier (SC-2) for BMP design details
- **Monitoring / Maintenance:**
- Inspect gravel bag berms before, during, and after each rain event, and weekly throughout the rainy season.
- Reshape or replace gravel bags, as needed.
- Repair washouts or other damages, as needed.
- Inspect gravel bag berms for sediment accumulations and remove sediments when accumulation reaches 1/3 of the berm height. Removed sediment shall be incorporated in the project.
- Remove gravel bag berms when no longer needed. Remove sediment accumulations and clean, re-grade, and stabilize the area.

Common Failures:

- Gravel bag berms not placed along contour.
- Gravel bags may degrade over time.

ROCK OR BRUSH FILTER – SC-5

Application: Linear barriers and perimeter controls, such as rock or brush filters, are temporary measures that intercept sediment-laden runoff and filter or trap sediment or non-storm water flows behind the barrier. Linear barriers and perimeter controls are the last line of defense before stormwater leaves the site, and must be carefully selected, properly installed, and diligently maintained.

Rock or brush filters are temporary barriers composed of brush, wrapped in filter cloth and secured in place, or rock anchored in place. They are intended to intercept and filter sediment-laden stormwater runoff from the disturbed area, retaining the sediment and releasing water as sheet flow, at a reduced velocity. These barriers are designed for sheet flow, not concentrated flow, and must not be placed across a stream or channel.

Design Guidelines: Use for contributing drainage areas less than or equal to 5 acres. Topography and drainage patterns are important considerations in the design of the linear barriers. Barriers shall be placed along a contour, and it is important that barriers be properly installed and keyed into the soil to prevent undermining (i.e., flow passing under the barrier). Use along the perimeter of disturbed areas; near the toe of slopes that may be subject to flow and rill erosion; around temporary spoil areas; along streams and channels; and across mildly sloped construction roads (rock filter berms, only).

Filters require sufficient space for ponded water because they allow water to seep through slowly. They are not effective for diverting runoff. Rock filter berms may difficult to remove when construction is complete.

Materials/Equipment: Site-cleared brush, woven-wire fabric, and wooden stakes; or clean rock.

Construction Specifications/Installation:

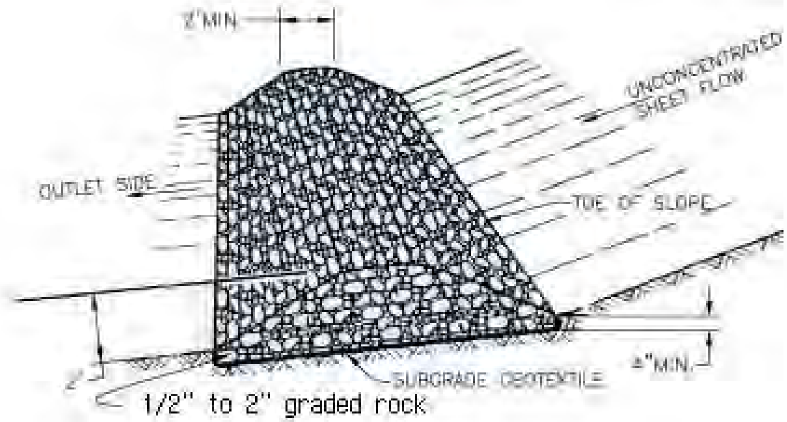
- Brush and rock filters shall be installed along a level contour.
- Provide adequate areas upstream of filter to accommodate ponding.
- Brush filters shall consist of site-cleared brush, or alternative material approved by engineer.
- Brush and rock filters shall be 3-5 feet in height and 5-15 feet in width at the base.
- Stakes: 1.5-inch x 1.5-inch wooden stakes, or metal stakes with equal holding capabilities.
- Woody fill: Woody debris shall be less than 6 inches in diameter. Install filter fabric over wood debris and anchor on the uphill side of slope in a 4-inch x 4-inch backfilled trench and anchor with stakes or sandbags on the downhill side of slope.
- Rock fill: open-graded rock, 0.75-5 inches for concentrated flow applications.
- Woven wire sheathing: 1 inch in diameter, hexagonal mesh, galvanized 20 gage (used with rock filters in areas of concentrated flow).
- In construction traffic areas, maximum rock berm heights shall be 12 inches. Multiple berms shall be constructed every 300 feet on slopes less than 100H:5V((5%), every 200 feet on slopes between 100H:5V (5%) and 100H:10V (10%), and every 100 feet on slopes greater than 100H:10V (10%).
- Rock and brush filters as well as other sediment barriers shall be installed along the contour at intervals noted in the Sediment Fence BMP, Table SC-1.1.

Monitoring / Maintenance:

- Inspect berms before and after each significant rain event, and weekly throughout the rainy season. Reshape berms as needed and replace lost or dislodged rock, brush and/or filter fabric.
- Inspect for sediment accumulation, remove sediments when depth reaches 1/3 of the berm height or 12 inches, whichever occurs first.
- Filter berms shall be removed upon completion of construction activities.

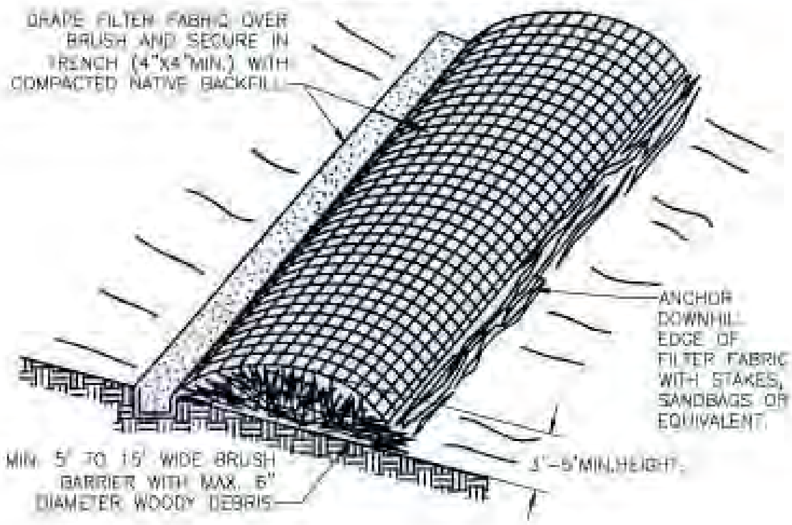
Common Failures:

- Filter material may become clogged.
- Brush filter will decompose over time.



FILTER BERM

BRUSH BARRIER



NOTES:

1. DIRECT THE OUTLET SIDE OF THE ROCK FILTER BERM/DAMS ONTO A STABILIZED AREA, SUCH AS VEGETATION AND OR ROCK.
2. EMBED A MIN. OF 4" INTO THE EXISTING GROUND/EMBANKMENT.
3. USE 3:1 OR FLATTER SIDE SLOPES WITHIN THE SAFETY CLEAR ZONE. USE 6:1 OR FLATTER SIDE SLOPES.

FILTER BERMS ROCK/BRUSH	SC-5

COMPOST BERMS AND SOCKS – SC-6

Application: A compost filter berm is a trapezoidal berm applied by a blower, and a compost sock is compost material encased in mesh to form a tube/roll. Both techniques intercept sheet flow and pond runoff, allowing sediment to fall out of suspension, and often filtering sediment as well. Compost berms and socks provide an environmentally-sensitive and cost-effective alternative to sediment fence. Compost binds heavy metals and can break down hydrocarbons into carbon, salts and other innocuous compounds.

Design Guidelines: Topography and drainage patterns are important considerations in the design of the linear barriers. Barriers shall be placed on the same contour, and it is important that barriers be properly installed and keyed into the soil to prevent undermining (i.e., flow passing under the barrier). Compost filter berms and socks shall only be used at the base of slopes 2H:1V or less. Compost berm or socks are for use in areas with sheet flow only and shall not be placed across streams or channels. They do not require any special trenching, construction, or removal, unlike sediment fence or coir rolls.

Materials/Equipment: Composted organic matter, biodegradable mesh. Specialized equipment is required, such as mechanical compost spreaders. Compost shall have the following specifications:

- Compost needs to be stable and mature.
- Particle size: Compost shall consist of both large and small pieces for maximum filtration. Finer grades (⅜ - ½ inch screened) are better for vegetation establishment, long term plant nutrients, and increased infiltration rates. Coarser grades (2-3 inch screened) are better for increased filtration, and are less likely to be dislodged by rainfall and runoff. For berms, the ratio of coarse and fine material shall be about 1:1. No particle shall be greater than 3 inches in diameter.
- The recommended moisture content ranges from 20-50%. Compost that is too dry is harder to apply, while that which is too wet is heavier and harder to transport. In Gresham, use compost with lower moisture content because it will absorb water.
- Organic matter content: The percentage of carbon based materials in finished compost shall range between 40-70%.
- The pH shall be between 5.0 and 8.5.
- Nitrogen Content: 0.5-2.0%.
- Compost shall have a minimum of soluble salts, as these can inhibit vegetation establishment. These levels shall be between 4.0 and 6.0 mmhos/cm.
- Compost must be weed and pesticide free, with manmade materials comprising less than 1%.

Construction Specifications/Installation:

- Compost berm sizing: On slopes of 3H:1V or less, install a compost berm 1-2 feet high and 2-4 feet wide at the base. For maximum filtration properties, install berm in a trapezoidal shape, with a 4-6 feet base, and a 2-3 feet wide top. Larger berms shall be used for steeper slopes. The basic rule of thumb is that the base should be twice the height of the berm.

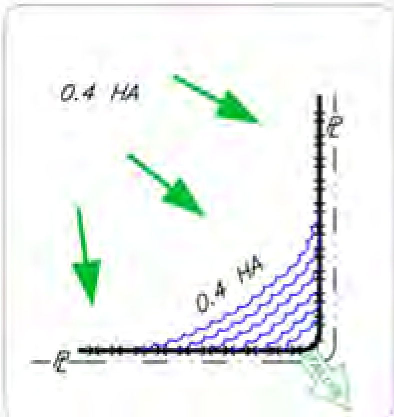
- Compost sock sizing: Typically, compost socks can handle the same water flow or slightly more than sediment fence. However, the installation technique is especially important for proper functioning. For most applications, a standard sediment fence replaced with a 12-inch compost sock.
  - Place on level contour so that sheet flow is perpendicular to the compost sock at the impact points. Do not place in areas of concentrated flow.
  - Compost socks shall be installed 5 feet or more from the toe of slopes to maximize space available for sediment deposition.
  - In order to prevent water flowing around the ends of compost socks, angle the ends upslope toward higher elevation.
- For perimeter control, compost berms and socks shall be placed on the contour. For irregular slopes or steep slopes, berms and socks shall be placed around the perimeter of affected areas using "smiles" and j-hooks (see BMP detail for an example). Do not place berms and socks where they cannot pond water. For steeper slopes, an additional berm or sock can be constructed on the top of the slope.
- For slope breaks, compost berms and socks shall be placed along the contour. See Sediment Fence BMP SC-1, Table SC-1.1 for spacing requirements.
- Compost berms and socks can be seeded during application. Do not cover seed with more than 2-4 inches of compost.
- Tackifiers may be applied to berms if needed to enhance performance.

Monitoring / Maintenance:

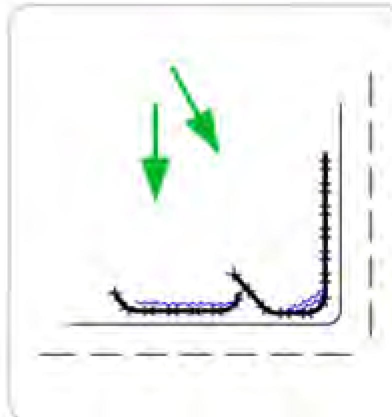
- Compost berms and socks shall be inspected after each storm event and reapplied if necessary.
- Sediment retained by the berm or sock shall be removed when it has reached 1/3 of the exposed height of the berm. Alternatively, the sediment and berm or sock can be stabilized with vegetation at the end of construction.
- Berms can be left on-site and seeded, or spread out in place as a soil enhancement.

Common Failures:

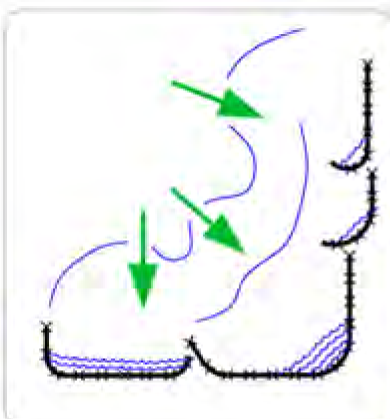
- Barrier not repaired after damage by heavy equipment.

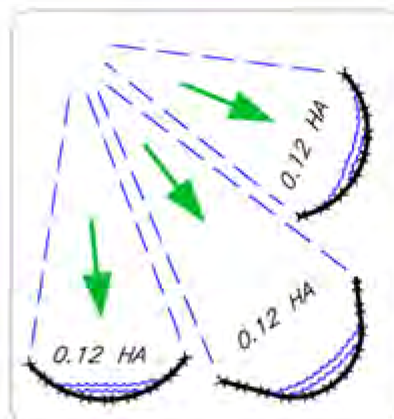


Incorrect – Do Not layout "perimeter control" compost berms along property lines. All sediment laden runoff will concentrate and overwhelm the system.



Correct – Install J–hooks

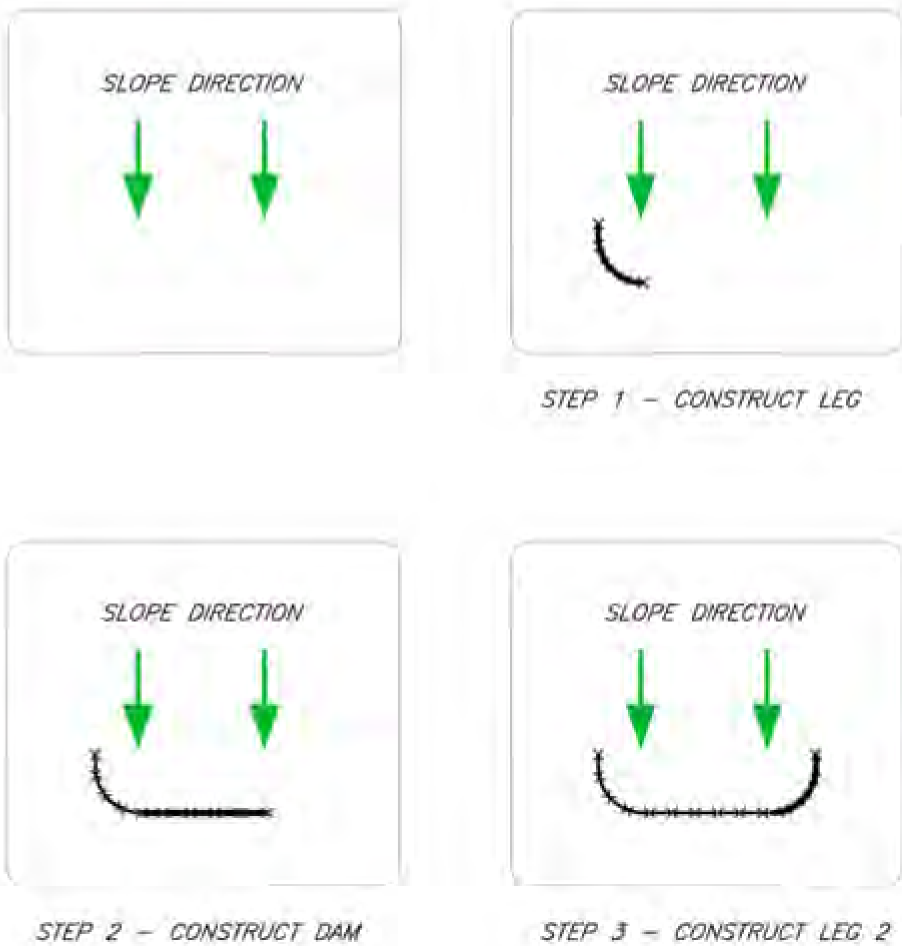




Discreet segments of compost berms, installed with J–hooks or 'smiles' will be much more effective.

COMPOST BERM PLACEMENT FOR PERIMETER CONTROL

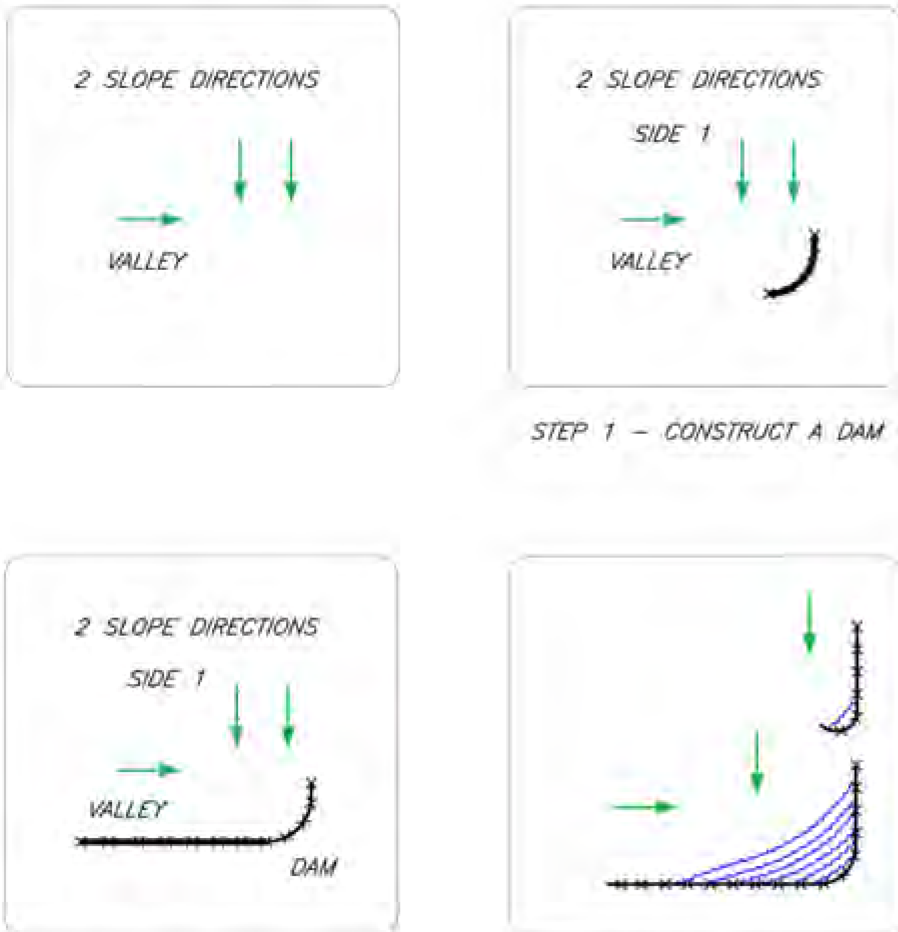
FILE: CB 1



INSTALLATION WITH J–HOOKS OR 'SMILES' INCREASE COMPOST BERM EFFICIENCY.

COMPOST BERM
TYPICAL PLACEMENT–ONE SLOPE

FILE: CB2



STEP 1 – CONSTRUCT A DAM

STEP 2 – CONSTRUCT SIDE 2

STEP 3 – CONSTRUCT J–HOOKS AS NEEDED

INSTALLATION WITH J–HOOKS WILL INCREASE COMPOST BERM EFFICIENCY AND REDUCE EROSION–CAUSING FAILURES.

COMPOST BERM
TYPICAL PLACEMENT–TWO SLOPES

FILE: CB 3

FIBER ROLLS OR WATTLES – SC-7

Application: Fiber rolls are small, cylindrical barriers composed of biodegradable fibers encased in photodegradable open weave netting. They are primarily identified as a sediment control measure used for perimeter or inlet protection, and also as an erosion prevention technique when used as slope breaks by being placed along the contours of the slope and staked into place. Fiber rolls are porous and allow water to filter through them. They intercept runoff, reduce flow velocity, release runoff as sheet flow, and provide some sediment retention. Fiber rolls create a favorable environment for plant establishment by interrupting the slope length and trapping soil and moisture. Also see Live Fascines and Brush Wattles (EP-16).

Appropriate applications for fiber rolls are at, in, or along:

- The face of exposed and erodible slopes to shorten slope length.
- The top of exposed and erodible slopes to spread runoff as sheet flow.
- Grade breaks where the slope transitions to a steeper gradient.
- Drainage swales to slow flows.
- Streambanks to assist stabilization and revegetation.

Design Guidelines: Fiber rolls are placed and staked along the contour of newly constructed or disturbed slopes, in shallow trenches. Appropriate sites are slopes susceptible to sheet and rill erosion, slopes producing dry ravel, slopes susceptible to freeze/thaw activity, and slopes difficult to vegetate because of soil movement.

As a linear barrier and perimeter control, fiber rolls and wattles are designed for sheet flow, not concentrated flow, and shall not be placed across a stream or channel. As temporary slope interrupter devices, they trap sediment and moisture on slopes until vegetation can provide long-term stabilization.

As slope breaks, fiber rolls reduce slope length, capture sediment, and reduce soil creep and rill erosion on slopes until permanent vegetation can be established. Fiber roles can capture organic matter, topsoil, seeds, and moisture to provide a stable medium for germination and growth.

Barriers shall properly installed by keying into the soil to prevent undermining (i.e., flow passing under the barrier).

- It is imperative, that a sufficient trench is constructed in which to place the roll. Without the trench, the roll will not function properly, runoff will scour underneath it, and trees or shrubs planted behind the roll will not have a stable environment in which to become established.
- Fiber rolls last for an average of two years, depending on the fiber and mesh used in manufacturing. This is an important factor to consider when planning for permanent slope stabilization.
- Fiber rolls can be staked with live stakes if the site conditions warrant. Moisture retained by the fiber roll will encourage live stakes to root.

Materials/Equipment: Fiber rolls are manufactured from biodegradable fibers (such as weed-free rice straw, coconut, or other approved material) that are wrapped in photo-degradable netting. They are approximately 8-20 inches in diameter and 25-30 feet long.

Construction Specifications / Installation:

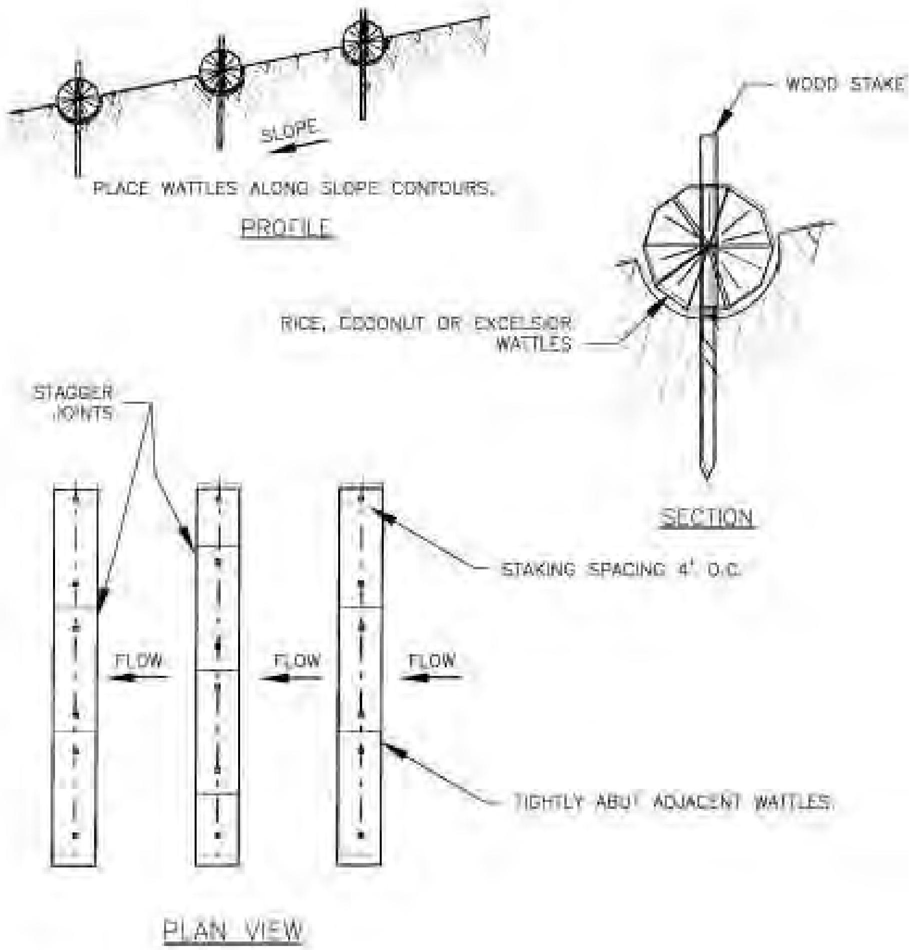
- The slope requires little preparation prior to the installation of fiber rolls or wattles. Rills and shallow gullies shall be smoothed as work progresses.
- Fiber rolls and wattles shall be installed along the contour and perpendicular to water movement.
- Dig shallow trenches across the slope and along the contour to place rolls. The trenches shall be deep enough to accommodate half the thickness of the roll. When the soil is loose or not compacted, the trench shall be deep enough to bury the roll 1/3 of its thickness because the ground will settle.
- Start building trenches and installing rolls from the bottom of the slope and work up.
- For slope breaks, fiber rolls and wattles shall be spaced according to the Sediment Fence BMP (SC-1), Table SC-1.1.
- For bioengineering, fiber rolls should be placed 25-30 feet apart depending on the steepness of the slope. The steeper the slope, the closer together the trenches shall be.
- Place rolls or wattles tightly against the soil in the trench, fitting them snugly against the soil. Make sure no gaps exist between the soil and the roll or wattle.
- For willow or wooden stakes, use a straight bar to drive holes through the roll and into the soil. Drive the stakes through the prepared holes, and into the soil at least 12 inches. Leave only 1-2 inches of the stake exposed above roll. Install stakes at least every 4 feet along the length of the wattle. Additional stakes may be driven on the downslope side of the trenches on highly erosive or very steep slopes.

Monitoring / Maintenance:

- Inspect the rolls and the slopes after rain events.
- Repair any rills or gullies promptly and make sure the rolls are in contact with the soil.
- Reseed or replant vegetation, if necessary, until the slope is stabilized.

Common Failures:

- Rolls lose function after one or two seasons.
- If not installed properly with a sufficient trench, rolls may fail during the first rain event.
- Stakes may not hold on steep slopes with sandy soil.



NOTES:

1. STAKING SPECIFICATIONS:
   a. 1"X2" WOODEN STAKES
   b. ADDITIONAL STAKES MAY BE INSTALLED ON DOWNHILL SIDE OF WATTLES, ON STEEP SLOPE OR HIGHLY EROSIVE SOILS.
2. Space in accordance with Table SC1-1.

FIBER ROLLS/WATTLES	SC-7

STORM DRAIN INLET PROTECTION – SC-8

Application: Temporary inlet protection must be provided for all active inlets for the duration of construction to keep sediment, trash, and other construction-related pollutants out of the storm drain system.

Design Guidelines: Identify existing and/or planned on-site and adjacent storm drain inlets that have the potential to receive sediment-laden surface runoff. Determine what the inlet types are and which method is appropriate to use. The specific types of BMPs are noted under Construction Specifications/Installation, below. BMPs shall be installed to properly to prevent sediment from entering the inlet.

Materials/Equipment: A variety of temporary inlet protection devices are available that are designed to be installed on soil, pavement, or inside the inlet, including: sediment insert bags; gravel bags, biobags, or bone bags; fiber rolls; block and gravel inlet protection; and filter fabric fence.

Construction Specifications/Installation:

Minimum specifications are provided on the Storm Drain Inlet Protection BMP details. The inlet protection Types 1-5 are designed to avoid most flooding. If a flooding problem occurs, modify the installed BMP to alleviate flooding. Do not remove the BMP to allow sediment-laden water to discharge to the storm drain.

Paved and Non-Paved Areas:

- Inlet Protection Type 1 – **Sediment Insert Bags** – The insert shall be installed per manufacturer's specifications. The Type 1 detail shows a Siltsack™ sediment insert bag. Storm drains with recessed curb inlets shall be blocked utilizing manufactured foam blocks to direct stormwater into the insert bag.
- Inlet Protection Type 2 – **Gravel bags, Biobags, or Bone Bag**s – Bag barriers shall surround the entire inlet. Ensure there are no gaps between bags, and that the bags are in contact with the pavement or ground. Gravel bags shall be constructed utilizing material specifications provided in the Gravel Bag Berm BMP (SC-3). Sand bags shall not be used for inlet protection.
- Inlet Protection Type 3 – **Fiber Rolls** – The fiber roll is placed around the inlet, keyed, and anchored to the surface similar to the installation technique of the Fiber Rolls and Wattles BMP (SC-7). On impervious surfaces, use weighted or gravel-filled fiber rolls as specified by the manufacturer.
- Inlet Protection Type 4 – **Block and Gravel** – The inlet shall be surrounded by cinder blocks with only the center block openings lying horizontally and perpendicular to the flow. All other block openings shall be aligned vertically. Fine wire mesh shall be placed between the blocks and gravel. Gravel shall be clean drain rock between ½ and 1 inch in diameter.

Non-Paved Areas Only:

- Inlet Protection Type 5 - **Filter Fabric Fence** - The filter fabric fence shall completely surround the inlet and be installed as shown in the BMP detail with protection provided in the space between the sediment fence and the inlet as illustrated. Similar to constructing a sediment fence (SC-1), the bottom of the fabric shall be toed-in 6 inches. Do not place filter fabric underneath the inlet grate—it cannot be maintained or removed without the collected sediment falling into the drain.
- Alternative methods will be considered on a site-by-site basis based on site characteristics, and require approval by the City.

Monitoring / Maintenance:

- Inspect all inlet protection devices before and after every rain event and weekly at active construction sites. During extended rain events, inspect inlet protection devices at least every 24 hours.
- Inspect the storm drain inlet for bypassed material after severe storms during the rainy season.
- When the site is stabilized:
  - Bring all disturbed areas to final grade. Appropriately stabilize all bare areas.
  - Inlets and stormwater systems must be cleaned prior to project finalization.

Type 1 - Sediment Insert Bags

- Inspect bags for holes and gashes. Replace as necessary.
- Clean and/or replace bags when capacity has been reduced by 50%, or bag is 1/3 full.

Type 2 - Bag Barriers

- Inspect bags for holes, gashes, and snags.
- Remove the sediment from behind the barrier when it reaches one-third the height of the barrier. Removed sediment shall be incorporated in the project or disposed of properly.
- Check gravel bags for proper arrangement and displacement.

Type 3 - Fiber Rolls

- Use weighted or gravel-filled fiber rolls on impervious surfaces. Check that fiber rolls are in good contact with the surface without gaps or preferential flow paths.
- Check fiber roll for proper arrangement and displacement. Remove the sediment behind the barrier when it reaches one-third the height of the barrier. Removed sediment shall be incorporated in the project or disposed of properly.

Type 4 - Block and Gravel

- Inspect for clogging and flooding.
- Remove and replace rock when flow becomes restricted.

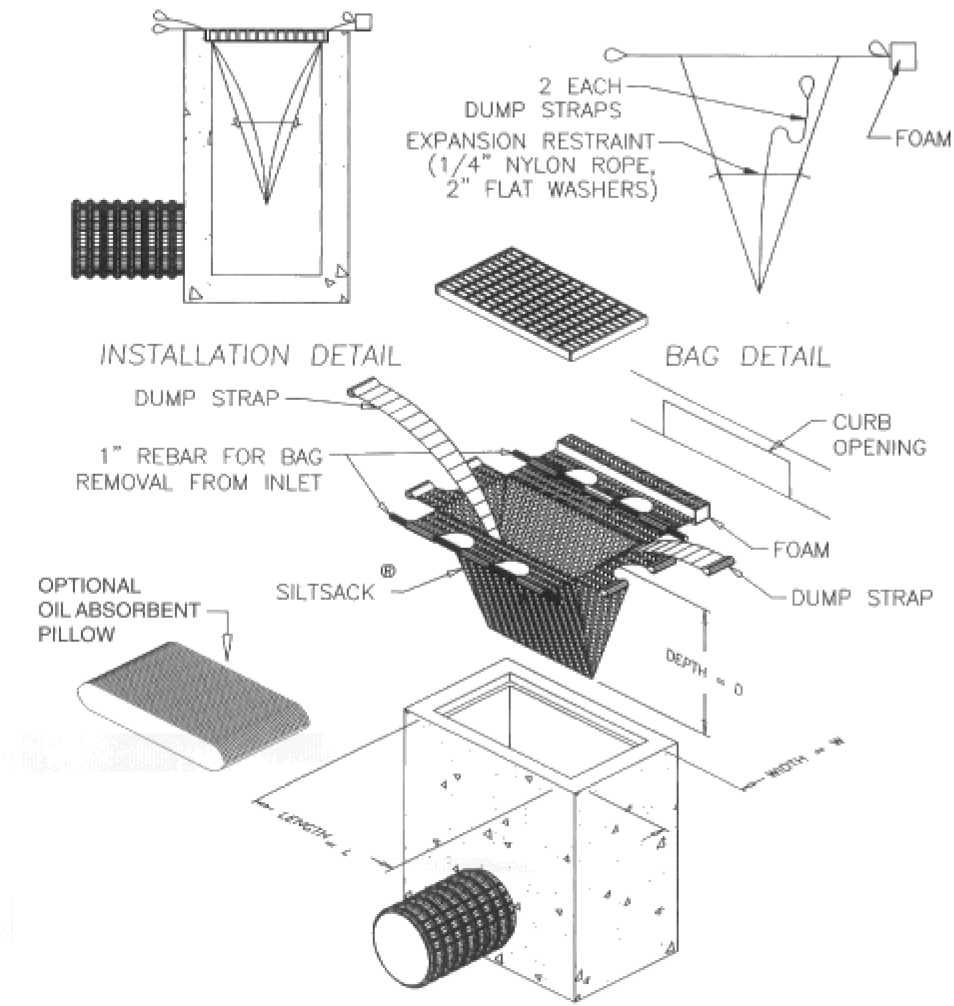
Type 5 - Filter Fabric Fence

- Make sure the toe of the fabric is buried 6 inches and the backfill is compacted.
- Make sure the stakes are securely driven in the ground and are structurally sound (i.e., not bent, cracked, or splintered, and are reasonably perpendicular to the ground). Replace damaged stakes.
- Replace or clean the fabric when the fabric becomes clogged with sediment. Make sure the fabric does not have any holes or tears. Repair or replace fabric, as needed.
- At a minimum, remove the sediment behind the fabric fence when accumulation reaches 1/3 the height of the fence. Removed sediment shall be incorporated in the project or disposed of properly.

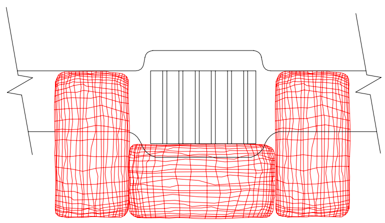
Common Failures:

- Trampling by equipment and traffic.
- Inadequate maintenance.

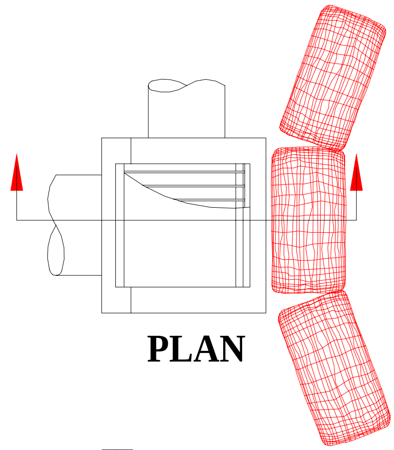
Typical Siltsack® Construction



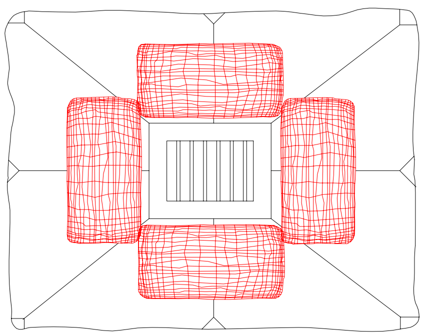
INLET PROTECTION – TYPE 1 SEDIMENT INSERT BAG	SC-8



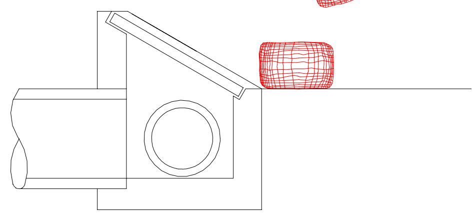
CATCH BASIN



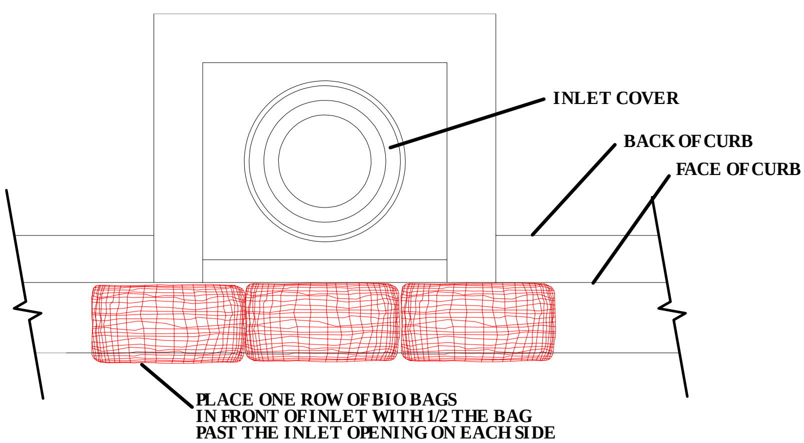
PLAN



AREA DRAIN



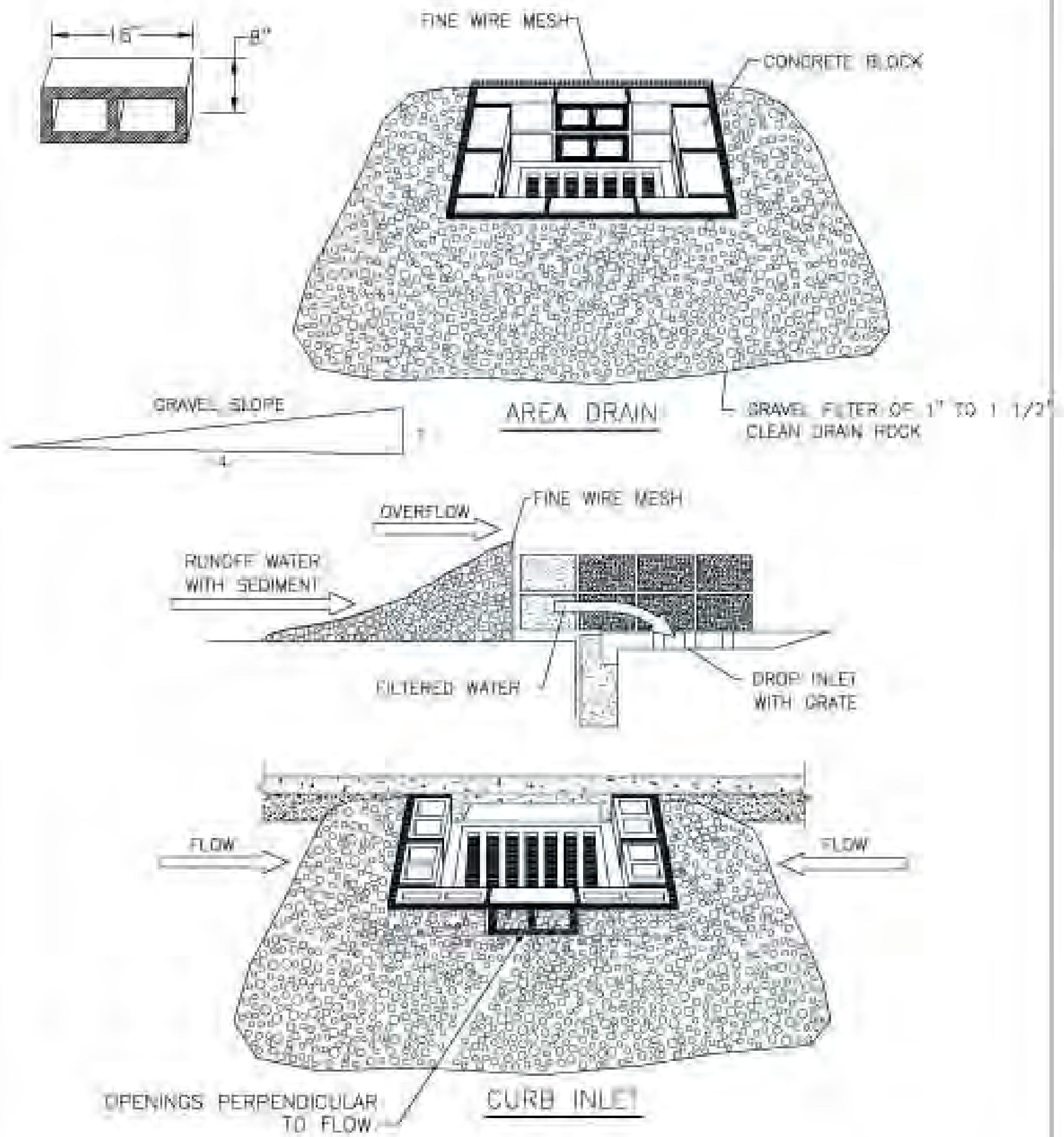
DITCH INLET



CURB INLET CATCH BASIN
BIO BAG INLET PROTECTION

NTS

INLET PROTECTION – TYPES 2 & 3 GRAVEL BAGS, FIBER ROLLS & BONE BAGS	SC-8

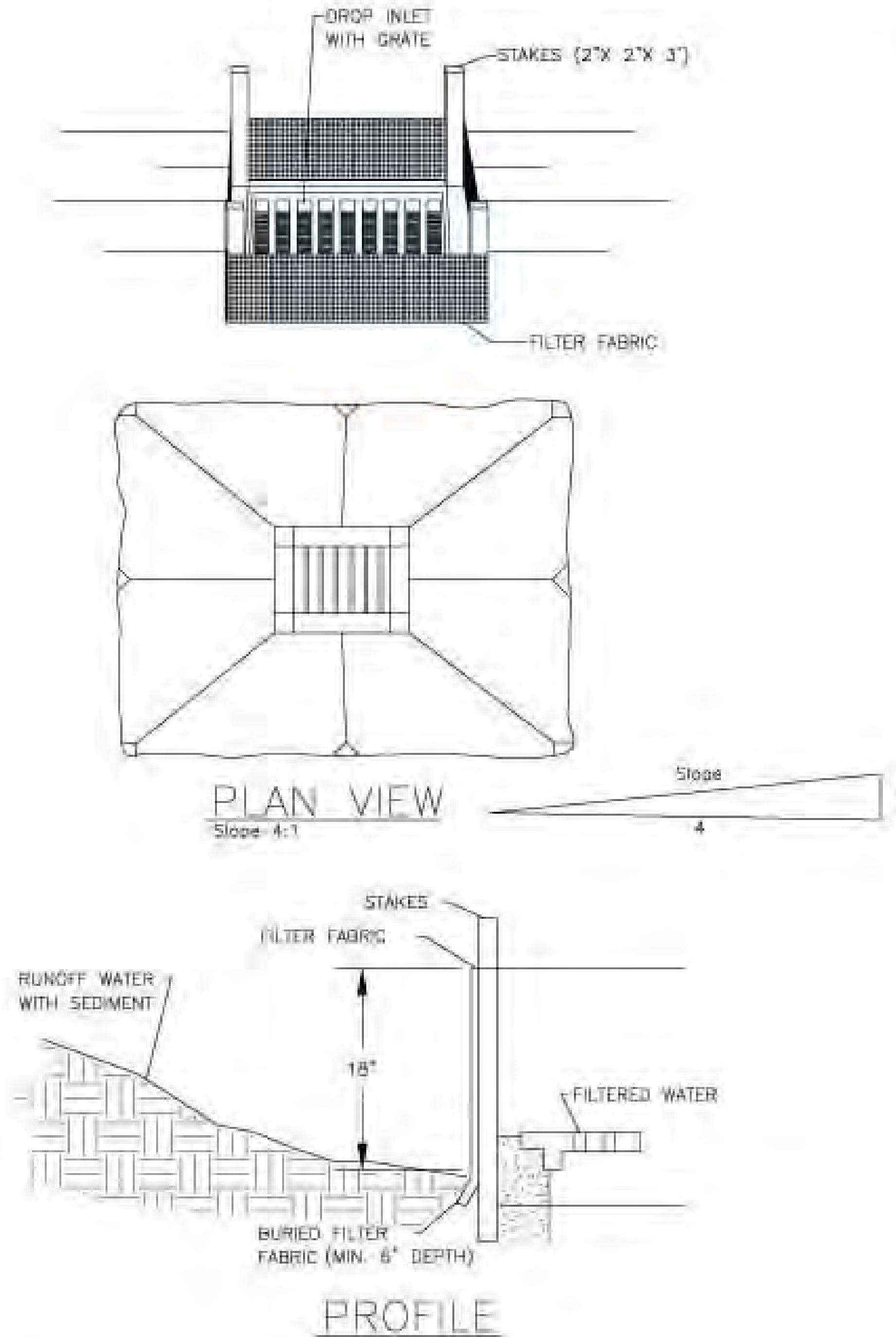


BLOCK AND GRAVEL INLET BARRIERS

NOTE:

1. BLOCKS SHALL BE STACKED WITH THE OPENINGS ON THE TOP AND BOTTOM EXCEPT FOR THE CENTER BLOCKS. CENTER BLOCKS WILL HAVE OPENINGS PERPENDICULAR TO FLOW.

INLET PROTECTION - TYPE 4 BLOCK & GRAVEL	SC-8



INLET PROTECTION - TYPE 5
FILTER FABRIC FENCE

SC-8

TEMPORARY SEDIMENT BASIN – SC-9

Application: A sediment basin is a temporary basin with a controlled release structure, formed by excavating or constructing an earthen embankment across a waterway or low drainage area. Sediment basins may be placed where sediment laden storm water may enter a storm drain or watercourse, and around and/or up-slope from storm drain inlet protection measures. Temporary sediment traps and basins are engineered temporary hydraulic controls that function by modifying the storm runoff hydrograph by: excavating below grade or by constructing an embankment to retain stormwater; capturing and detaining sediment-laden stormwater runoff from the site, thus providing an opportunity for suspended soil particles to gravitationally settle out; and providing a temporary storage device for the captured sediment.

Design Guidelines: All basins shall have an outlet device to release the water in a controlled manner and a stabilized emergency spillway for overflow. Outlet devices shall be sized to empty the basin within 48 hours. Basins shall be sized to retain 3,600 cubic feet per acre for the contributing watershed. Additional capacity shall be added to store accumulated sediment between maintenance clean-outs. All engineered structures must be designed by a professional engineer licensed in the State of Oregon.

Sediment basins are typically not recommended for sites with fine-grained soils such as silts and clays. Because these soils will stay in suspension for a long time, it may not be feasible to hold the water long enough for fine-grained suspended sediment to settle out of suspension without additional treatment (i.e., flocculants; vegetation). The use of flocculants will be considered by the City on a site-by-site basis. Vegetation is required for sediment ponds designed as a permanent detention structure. Vegetation may be required on temporary ponds.

The removal efficiency of sediment basins can be enhanced by using baffles, skimmers, or other devices to lengthen the flow path and/or improve the removal of suspended particles. The placement of baffles in a sediment basin creates a longer flow path through the basin, resulting in a longer holding time and increased potential for settling particulates. A skimmer is an alternative to slotted riser outlet pipes. It is device that is attached to the sediment basin outlet and floats on the water surface above the settling zone. The skimmer has a designed orifice size that drains water out of the pond at a specified rate.

The basin configuration also has an effect on sediment performance. To improve the sediment trapping efficiency of the basin, the effective flow length shall be twice the effective width. This basin shape may be attained by optimal site selection or by the use of baffles. The inlet shall be at the opposite end from the outlet, either by design or by the use of baffles.

Materials/Equipment: Culvert, riser, skimmer, excavation equipment, and flocculants, as required.

Construction Specifications/Installation: The sediment basin shall follow one of the four design options summarized below:

Option 1: A sediment basin designed pursuant to local ordinance provided that the design efficiency is as protective, or more protective of water quality than Option No. 3.

Option 2: A sediment basin designed with a minimum capacity of 3,600 cubic feet of storage per acre of disturbed land in a watershed equivalent to or more efficient than Option No. 3.

Option 3: A sediment basin designed using the following equation:

$$(V) = 1.2Q/V_{SED}$$

Where:

V = settling zone volume

Q = flow rate based on peak discharge from a specified design storm (where Q = CiA)

V_{SED} = settling velocity of the design soil particle

Option 4: A basin designed using an equivalent surface area design equation, equivalent to or more efficient than Option No. 3.

The following specifications shall apply to all four options:

- In accordance with the requirements of the NPDES 1200-C General Permit, all sediment basins must be designed by a professional engineer licensed in Oregon.
- Construct the basin by excavating or building an embankment before any clearing or grading work begins.
- Areas under the embankment and any structural works shall be cleared, grubbed and stripped of any vegetation and rootmats as shown on the grading plan.
- A cut-off trench shall be excavated along the centerline of the earth fill embankments. The minimum depth shall be 2 feet. The cut-off trench shall extend up both abutments to the spillway elevation.
- Fill material for the embankment shall be clean mineral soil free of roots, woody vegetation, oversized stones, rocks or other objectionable material, and sufficiently moist for compaction.
- Fill material shall be placed in 6-inch lifts, continuous layers over the entire length of the fill. Compaction shall be obtained by routing the hauling equipment over the fill so that the entire surface of each layer of the fill is traversed by at least one wheel or tread track of the equipment, or by the use of a compactor.
- The embankment shall be constructed to an elevation of 10% higher than the design height to allow for settlement if compaction is achieved with hauling equipment. If compactors are used for compaction, the overbuild may be reduced to not less than 5%. The basin shall have means for dewatering within 7 days following a storm event.
- The principal spillway riser shall be securely attached to the discharge pipe by welding all around. All connections shall be watertight. A trash rack shall be installed on the top of the riser to prevent clogging of the discharge pipe.
- The pipe and riser shall be placed on a firm, smooth soil foundation. The connection between the riser and the riser base shall be watertight. Pervious materials such as sand, gravel or crushed stone shall not be used as backfill around the pipe or anti-seep collars.
- The fill material around the pipe spillway shall be placed in 4-inch layers and compacted under the shoulders and around the pipe to at least the same density as the adjacent embankment. A minimum of
2 feet of compacted backfill shall be placed over the pipe spillway before crossing it with construction equipment.
- Steel base plates shall have at least 2 ½ feet of compacted earth, stone or gravel over them to prevent flotation.
- The emergency spillway shall not be installed in fill. Elevations, design width, and entrance and exit channel slopes are critical to the successful operation of the emergency spillway.
- If used, baffles shall be constructed of 4-inch by 4-inch posts, and 4-foot by 8-foot, ½-inch thick, exterior plywood. The posts shall be set at least 3 feet into the ground, no further apart than 8 feet, center to center, and shall reach a height 6 inches below the riser crest elevation. Alternatively, earthen berms, metal sheeting, or other methods may be used after approval by the City.

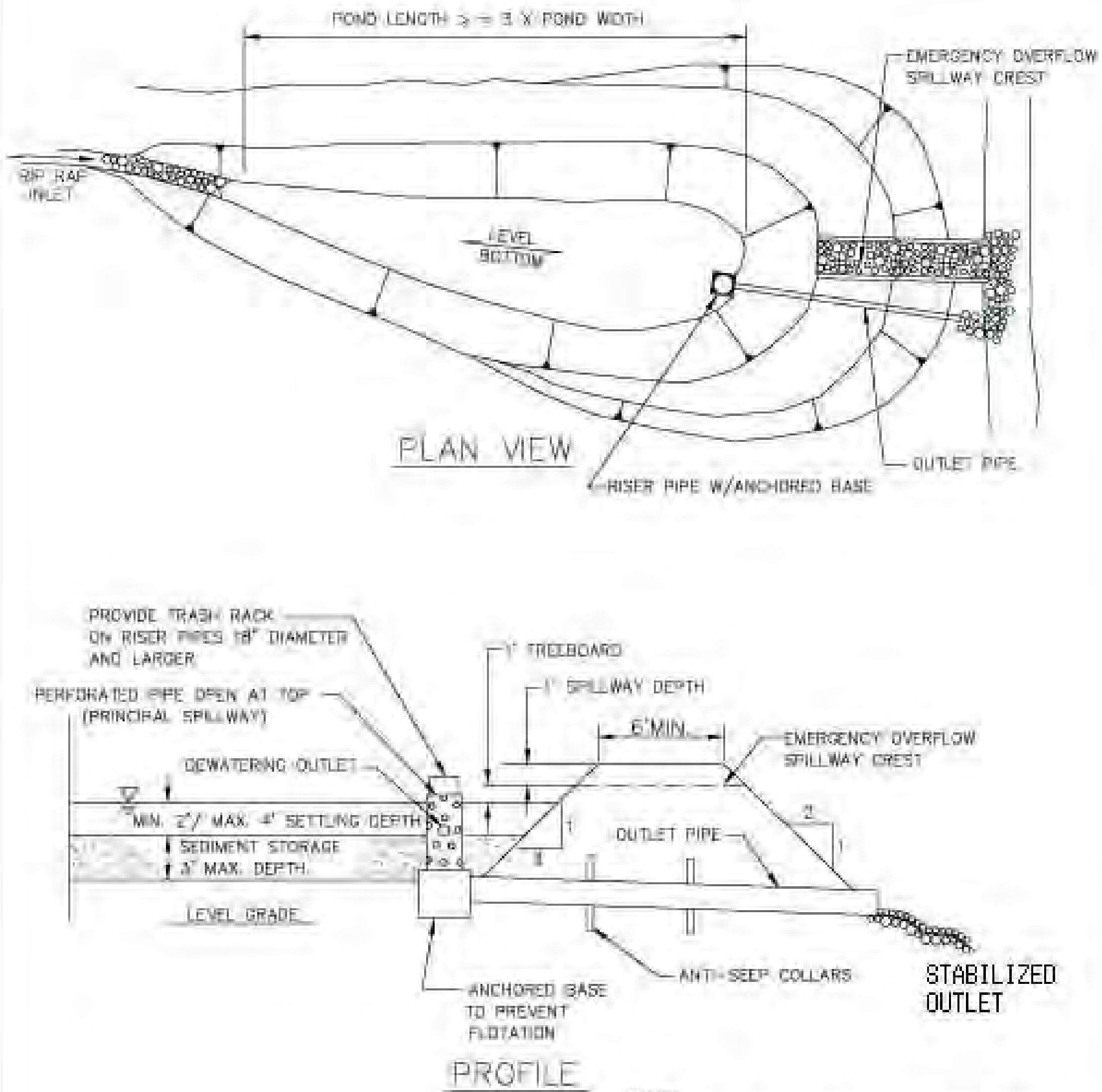
- The embankment and emergency spillway shall be stabilized with vegetation immediately following construction. The outflow shall be provided with outlet protection to prevent erosion and scour of the embankment and channel.
- Construction operations shall be carried out in such a manner that erosion and water pollution will be minimized.
- City and state requirements shall be met concerning fencing and signs warning the public of hazards of soft sediment and floodwater.
- Flocculants may be added to the water in a sediment basin to increase the suspended sediment settling rate. Accepted flocculants include gypsum (a natural mineral product) and chitosan (a shellfish product). Other materials will be considered by the City and approved on a site-by-site basis. Manufacturers' recommendations shall be followed regarding rates of application and care shall be taken to avoid the release of flocculants from the basin.
- Electrocoagulation may be used to remove suspended solids and other contaminants from storm water runoff. It is a process whereby a controlled electrical current is passed through the water, which causes the suspended particulates to become charged and bond together to form larger masses that settle to the bottom. This process is effective on any size of suspended solids, including submicron particles, and is typically combined with filtration to enhance effectiveness.

Monitoring / Maintenance:

- All sediment traps require continued maintenance to function properly. Excess sediment shall be removed to ensure basin capacity and trap efficiency.
- Inspect before, during, and after each rain event.
- All damage caused by soil erosion or construction equipment shall be repaired before the end of each working day.
- Sediment basins must be cleaned out when the sediment storage zone is half full. Sediment removed from basins must be placed, compacted, and stabilized to avoid erosion and re-mobilization. The sediment shall not be deposited downstream from the embankment, or in or adjacent to a stream or floodplain. If there is a potential for the sediment to be contaminated, it must be tested and disposed of properly.
- When temporary structures have served their intended purpose and the contributing drainage area has been properly stabilized, the embankment and resulting sediment deposit shall be leveled or otherwise disposed of in accordance with the approved Plan.

Common Failures:

- Inadequate sizing.



NOTE:
MINIMUM OF 50' OF WELL VEGETATED AREA AND A SEDIMENT BARRIER OR FLOW SPREADER IS REQUIRED PRIOR TO DISCHARGE TO A STREAM OR WETLAND

SEDIMENT BASIN	SC-9

CONSTRUCTION ENTRANCE / EXIT TRACKING CONTROLS – SC-10

Application: Tracking controls reduce offsite tracking of sediment and other pollutants by providing a stabilized surface at defined construction site entrances and exits. Also, they include sweeping or vacuuming to prevent sediment or other materials from entering a storm drain.

Design Guidelines: Stabilized entrances shall be implemented for all construction projects. Sweeping or vacuuming shall be implemented when sediment is tracked from the project site to public or private paved roads, typically near exit locations.

Materials/Equipment: Properly-sized aggregate and geotextile fabric.

Construction Specifications/Installation:

Stabilized Construction Entrances and Exits

- Limit the points of entrance/exit to the construction site by designating combination or single purpose entrances and exits. Require all employees, subcontractors and others to use them. Limit speed of vehicles to control dust. Clearly mark entrances and exits with appropriate signage.
- Locate construction entrances and exits to limit sediment leaving the site and to provide for maximum utility by all construction vehicles. Avoid entrances at steep grades or at curves in public roads.
- Grade each construction entrance/exit to prevent runoff from leaving the construction site.
- Design the stabilized entrance/exit to support heaviest vehicles and equipment that will use it.
- The length of the pad shall not be less than 50 feet long and long enough for at least 4 to 5 wheel rotations of the largest vehicle or equipment at the site.
- The width of the pad shall not be less than the full width of all points of ingress or egress and shall not be less than 20 feet wide.
- The thickness of the pad shall not be less than 8 inches
- The aggregate size for construction of the pad shall be 3-6 inch stone. However, ¾ inch minus aggregate is allowable for single-family and duplex construction entrances. Place the gravel to the specific grade and dimensions shown on the plans and smooth it.
- Geotextile fabric is required for stability under the aggregate for all construction entrances, except single-family and duplex projects.
- All sediment spilled, dropped, washed, or tracked onto public rights-of-way shall be removed as soon as possible by hand sweeping, mechanized sweeper, or vacuum. Washing of sediment from the public right-of-way shall be prohibited.
- When off-site tracking cannot be controlled, wheels shall be cleaned to remove sediment before exiting to public rights-of-way (see Tire Wash, SC-11).
- All sediment shall be reduced or prevented from entering any storm drain, ditch, or watercourse through use of sediment fence, gravel bags, sediment barriers, or other approved methods.

Entrance with Shaker Plates

- The use of constructed or manufactured steel plates with ribs (e.g., shaker/rumble plates, corrugated steel plates) for entrance/exit access is allowable. Incorporate with a stabilized construction entrance/exit.
- Construct on level ground when possible, on a coarse (6-3 inch) aggregate pad. Geotextile fabric shall be placed below the aggregate.
- Install constructed or manufactured steel plates with ribs at the entrance/exit in addition to the aggregate.

- Steel shaker plates shall be designed and constructed/manufactured for anticipated traffic loads.

Street Sweeping and Vacuum Sweeping

- Inspect any areas of potential sediment tracking daily.
- Visible sediment tracking shall be swept or vacuumed daily and more often as necessary. Manual sweeping is appropriate for small jobs.
- For larger projects, use mechanical broom or vacuum sweepers that collect and contain removed sediment and material.
- If not mixed with debris or trash, incorporate the removed sediment back into the project or depose of it at an approved disposal site.

Monitoring / Maintenance:

Stabilized Construction Entrance

- Inspect routinely for damage and assess effectiveness. Repair if access is clogged with sediment.
- Where tracking has occurred on roadways, sweeping shall be conducted the same day. Water shall not be used to wash sediment off the streets it can be captured and disposed of properly (i.e., vacuum sweeper).
- Keep all temporary roadway ditches clear.
- The entrance shall be maintained in a condition that will reduce or prevent tracking or flowing of sediment onto public rights-of-way. This may require periodic top dressing with additional stone as conditions demand, and repair and/or maintenance of any measures used to trap sediment.
- Maintain the gravel pad in a condition to prevent mud or sediment from leaving the construction site. Replace gravel material when surface voids are visible.
- After each rainfall, inspect all gravel construction entrances and clean, as necessary.
- Remove all objectionable materials or sediments spilled, washed, or tracked onto public roadways immediately or as soon a practicable.

Street Sweeping and Vacuuming

Inspect entrance and exit points daily and sweep tracked sediment as needed.

Be careful when handling any unknown substance or any object that may be potentially hazardous.

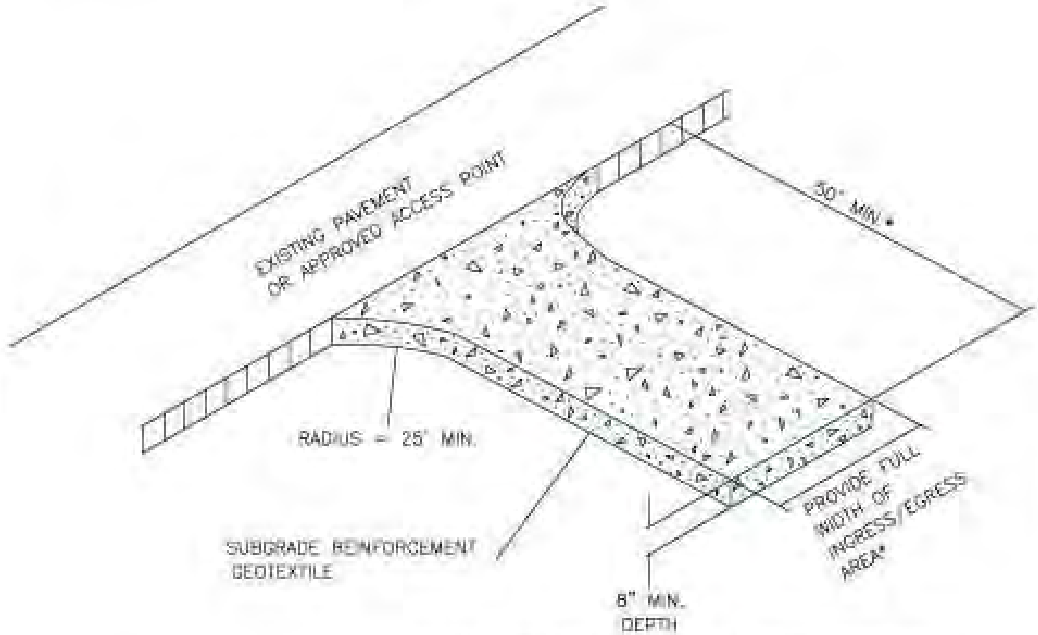
After sweeping is finished, properly dispose of sweeper wastes.

All sediment spilled, dropped, washed, or tracked onto public rights-of-way must be removed as soon as possible, and at least daily. Visible sediment tracking shall be swept or vacuumed as needed. Manual sweeping is appropriate for small jobs. For larger projects, use mechanical broom or vacuum sweepers that collect and contain removed sediment and material. Washing of sediment from public rights-of-way shall be prohibited. If not mixed with debris or trash, the removed sediment may be used on the project site or deposed of at an approved disposal site.

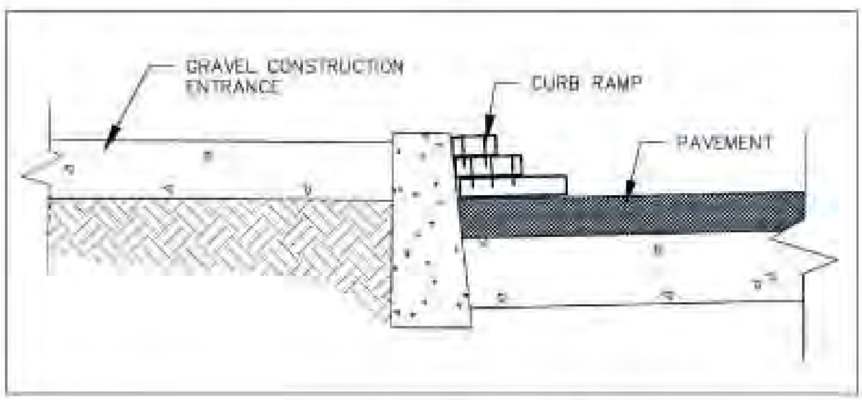
Common Failures:

Failure to outslope runoff to controlled detention area.

Lack of maintenance.



*20' MIN. FOR SINGLE FAMILY AND DUPLEX RESIDENTIAL



NOTES:

DIMENSIONS

SINGLE FAMILY
20' LONG BY 20' WIDE
8" DEEP OF ¾" MINUS CLEAN ROCK.

COMMERCIAL
50' LONG BY 20' WIDE
3-6" CLEAN ROCK.

CONSTRUCTION ENTRANCE	SC-10

TIRE WASH – SC-11

Application: When off-site tracking cannot be controlled, wheels shall be cleaned to remove sediment prior to exiting to public rights-of-way. The tire wash may be a drive-through facility, or a hose and wash pad.

Design Guidelines: Tire washes may be either Manual/Hose or Temporary Drive-Through. All employees, subcontractors, and others that leave the site with mud-caked tires or under-carriages must use the wheel wash facility. The wheel wash, which should be incorporated with a stabilized construction entrance, must be designed and constructed for anticipated traffic loads.

Materials/Equipment: Water supply, crushed rock, corrugated steel panels, and filter fabric.

Construction Specifications/Installation:

- Incorporate with Construction Entrance/Exit Tracking Controls (SC-10).

Manual/Hose Tire Wash

- Construct on level ground when possible, and on a pad of coarse (3-6 inch) aggregate. A geotextile fabric shall be placed below the aggregate.
- Tire wash shall be designed and constructed/manufactured for anticipated traffic loads.
- Drainage shall be conveyed from the wash area to a sediment trapping device. The drainage ditch shall be of sufficient grade, width, and depth to carry runoff from the wash.
- Require that all employees, subcontractors, and others who leave the site with mud-caked tires or under-carriages use the wash facility.

Temporary Drive-Through Tire Wash

- Minimum dimensions: 40 feet long by 12 feet wide by 1.5 feet deep. The minimum length includes ingress and egress from the sump.
- The aggregate size for construction of the pad shall be 3-6 inch stone. Place the gravel to the specific grade and dimensions shown on the plans, and smooth it.
- The thickness of the pad shall not be less than 8 inches. Use geotextile fabric under the gravel to improve stability of the foundation.
- Alternatively, install a 3-inch asphalt lift over a stable roadway base with the same dimensions as above.
- The run out pad shall extend 50 feet past the egress ramp and drain back into a sump or suitable collection and treatment facility.
- Install fencing, as necessary, to manage vehicle traffic.

Monitoring/Maintenance:

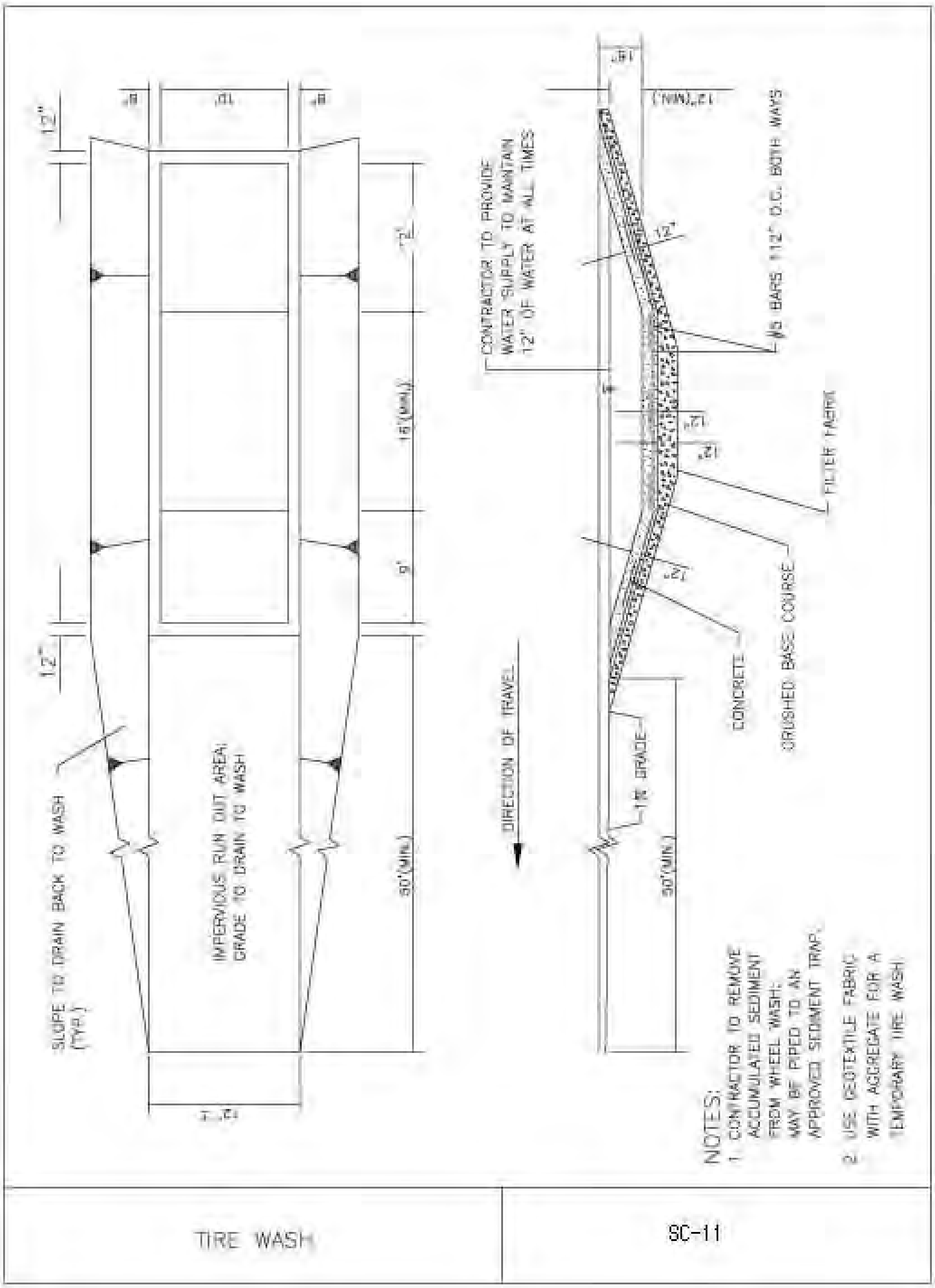
Manual/Hose Tire Wash

- Remove accumulated sediment in tire wash and sediment trap to maintain system performance.
- Inspect routinely for damage. Clean or replace rock, as needed.

Temporary Drive-Through Tire Wash

- Inspect routinely to assess the water levels within the sump, the depth of accumulated sediment, and identify any areas that require maintenance.

- Remove accumulated sediment from the tire wash facility to maintain tire wash sump depth. Sediment may be pumped, piped, or vacuumed to a suitable collection and treatment facility.
- Clean or replace rock when clogged with sediment and re-grade, as needed.
- Maintain the run-out pad as necessary to prevent sediment accumulation.
- Immediately remove any rock that is carried from the pad to the roadway.
- Ensure that wash water drainage, collection, and treatment is functioning.


SLOPE TO DRAIN BACK TO WASH (TYP.)
IMPERVIOUS RUN OUT AREA; GRADE TO DRAIN TO WASH
12"
12"
8'
10'
8'
12'±
9'
16'(MIN.)
9'
50'(MIN.)
DIRECTION OF TRAVEL
CONTRACTOR TO PROVIDE WATER SUPPLY TO MAINTAIN 12" OF WATER AT ALL TIMES
#5 BARS @12" O.C. BOTH WAYS
12"(MIN.)
18"
12"
12"
12"
12"
FILTER FABRIC
CRUSHED BASE COURSE
CONCRETE
1% GRADE
50'(MIN.)
NOTES:
1. CONTRACTOR TO REMOVE ACCUMULATED SEDIMENT FROM WHEEL WASH; MAY BE PIPED TO AN APPROVED SEDIMENT TRAP.
2. USE GEOTEXTILE FABRIC WITH AGGREGATE FOR A TEMPORARY TIRE WASH.
TIRE WASH
SC-11

UNDERCUT LOTS/SIDEWALK SUBGRADES – SC-12

Application: Undercut lots or sidewalk subgrades are linear drainage barriers that provide an effective sediment filtration and retention area behind the curb.

Design Guidelines: Topography and drainage patterns are important considerations in the design of the under cut lots as linear barriers.

Materials/Equipment: Concrete curb or pavement, sub-base material, and excavation equipment.

Construction Specifications/Installation:

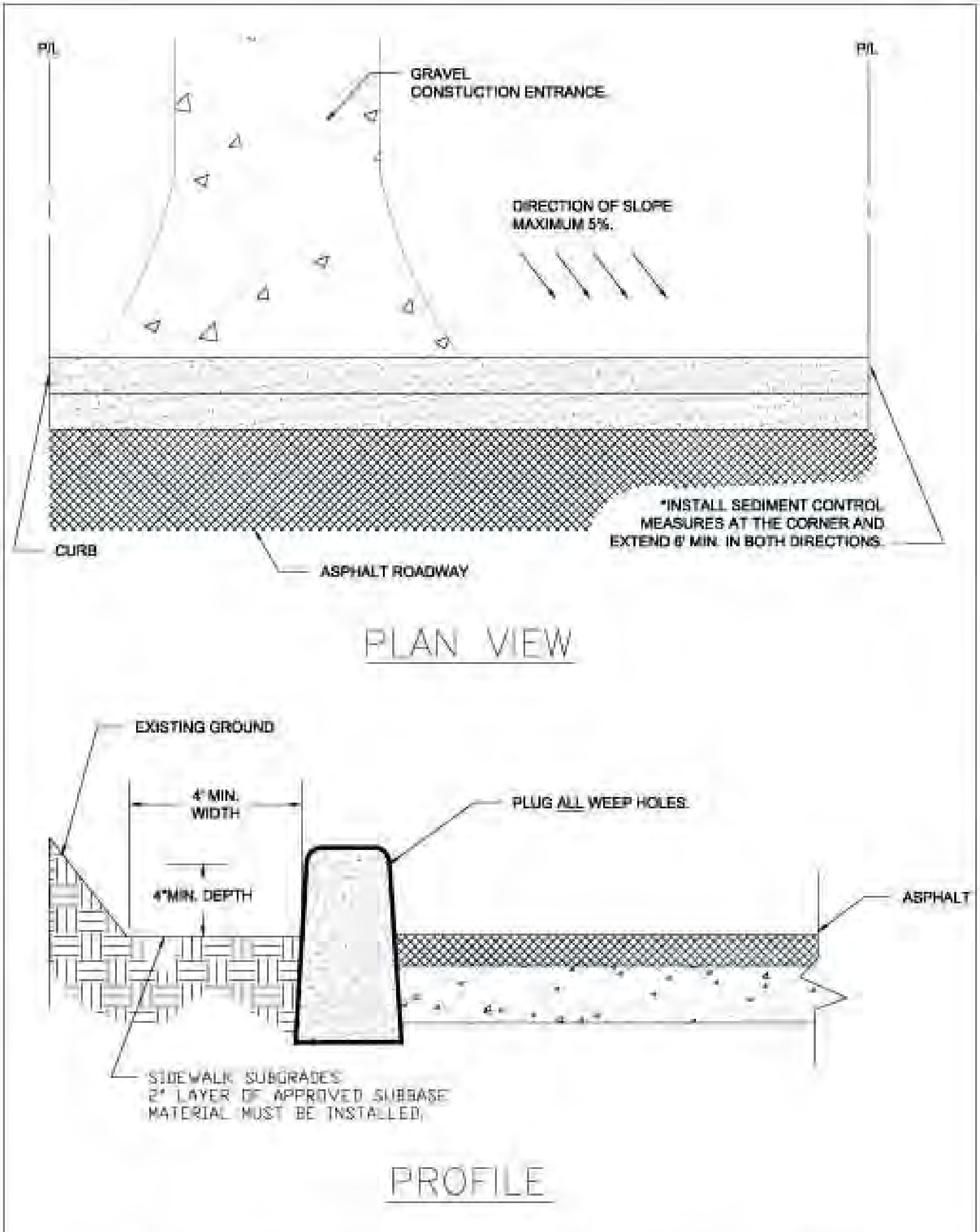
- Cut back soil from curb 2-4 inches deep and 4 feet wide to form a temporary sediment trap.
- Place a 2-inch layer of aggregate sub-base.
- Weep holes in curb must be plugged.
- If sidewalk is to be poured prior to site stabilization, alternative sediment barriers must be installed.

Monitoring/Maintenance:

- Inspect weekly, and prior to and after rain events.
- Maintain as needed.
- Remove accumulated sediment and replace aggregate when filtering capacity is reduced by 50 percent or aggregate is clogged with sediment.

Common Failures:

- Lack of maintenance.



Note: Sidewalk subgrade can be used for all construction activities.

UNDERCUT LOTS/SIDEWALK SUBGRADE	SC-12

TEMPORARY SEDIMENT TRAP – SC-13

Application: A sediment trap consists of a small, temporary area engineered for ponding water. Sediment-laden water is trapped by a rock weir or perforated riser pipe at the outlet. Sediment traps are excavated below grade or constructed above by using an embankment. Stormwater runoff is captured and detained in the trap, providing the opportunity for suspended soil particles to gravitationally settle out and for temporary sediment storage.

Design Guidelines: A sediment trap is designed to remove sediment from runoff by holding a volume of water for a length of time, allowing particles 0.0008 inch and larger to settle out. Sediment traps should be used as a last line of defense and never as a stand-alone measure.

Sediment basins are recommended for sites with coarse-grained soil. Fine-grained silts and clays will stay in suspension too long, and it may not be feasible to hold the water long enough for fine-grained suspended sediment to settle out of suspension (without treatment by flocculants or vegetation).

Materials/Equipment: Rock, aggregate, and geotextile fabric.

Construction Specifications/Installation:

- Construct prior to upslope clearing and grading.
- Locate in a low area where the trap will intercept all or most of the runoff from the disturbed area before it enters a waterway.
- Provide for temporary diversion swales (RC-3) or dikes (RC-4) to collect and divert water to the trap.
- Sediment storage volume can be calculated using the RUSLE, assuming a minimum one-year sediment accumulation period for design purposes. (To convert tons of sediment to cubic-foot volume, assume 0.05 ton of sediment per cubic foot.)
- Determine the bottom surface area of the sediment trap using the calculated sediment volume and the maximum 1½ foot depth for sediment storage.
- Determine the total trap dimensions by adding an additional 2 feet of depth for settling volume (before overtopping of spillway) above the sediment storage volume, while not exceeding 3H:1V side slopes.
- Design the trap with a level bottom and 3H:1V or flatter side slopes.
- Form the trap by excavation or by construction of compacted embankment. If the trap is formed by embankment, dam safety regulations may apply to embankment heights exceeding 5 feet. The embankment should be stabilized using a cover method such as seeding, mulching, or matting.
- Evaluate the release areas on a site-by-site basis in order to determine appropriate locations for and methods of releasing runoff.

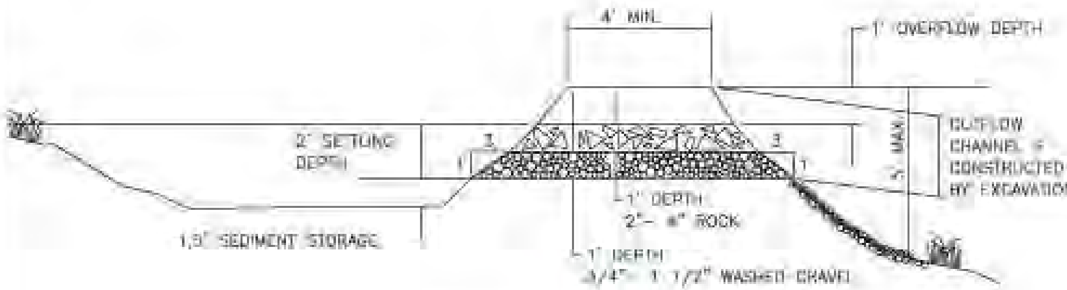
Monitoring/Maintenance: All sediment traps require continued maintenance to function properly. Excess sediment shall be removed to ensure basin capacity and trap efficiency.

- Inspect before, during, and after each rain event.
- All damage caused by soil erosion or construction equipment shall be repaired before the end of each working day.
- Remove sediment when the sediment storage zone is 1/3 full. This sediment shall be placed in such a manner that it will not erode from the site. The sediment shall not be deposited downstream from the embankment, or in or adjacent to a stream or floodplain.

- When temporary structures have served their intended purpose and the contributing drainage area has been properly stabilized, the embankment and resulting sediment deposit shall be leveled or otherwise disposed of in accordance with the approved Erosion Prevention and Sediment Control Plan.

Common Failures:

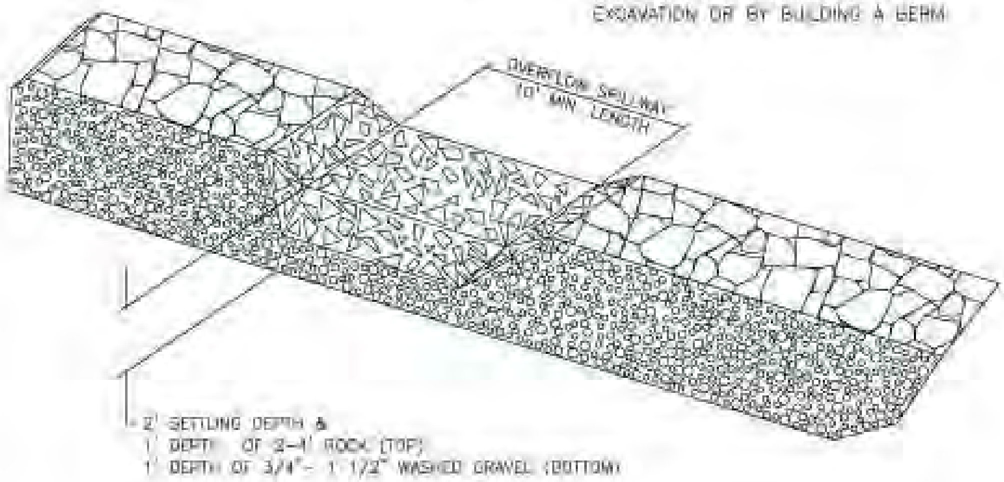
- Inadequate sizing.
- Lack of maintenance.



CROSS SECTION

NTS

NOTE: MAY BE CONSTRUCTED BY EXCAVATION OR BY BUILDING A BERM



SEDIMENT TRAP OUTLET

NTS

NOTE:
A SEDIMENT BARRIER OR FLOW SPREADER IS REQUIRED BEFORE DISCHARGING TO A VEGETATED AREA OR OFFSITE

SEDIMENT TRAP	SC-13

Chapter 6 Non-Stormwater Pollution Controls

6.1 Overview

This chapter defines and identifies the Plan requirements for non-stormwater pollution controls and summarizes individual control measures. The City of Gresham requires the Plan to include BMPs for non-stormwater discharges. <u>These BMPs must be in-place at all times during construction.</u>

6.2 Definition of Non-Stormwater Pollution Controls

Non-stormwater pollution controls consist of general site and materials management measures that directly or indirectly aid in minimizing the discharge of sediment and other construction related pollutants from the job site. Construction site work activities can generate a variety of pollutants, many of which are summarized in Table 6.2.1.

Special care and attention shall be given to chemicals and other potentially hazardous materials to ensure proper containment, spill control, and disposal.

Required non-stormwater pollutant control measures:

- Areas used for storage of soils or wastes.
- Stockpile protection.
- Non-stormwater pollution control measures to prevent or minimize exposure to spills, cleaning and maintenance activities, and waste handling.

* Controls shall also be included for the following additional activities:
    - Proper material handling, use, and storage
    - Vehicle and equipment cleaning, fueling, and maintenance
    - Paving and concrete management
    - Contaminated soil management
    - Ponded water management
    - Any other activity with the potential to contribute to offsite pollutant discharges.

TABLE 6.2.1. CONSTRUCTION WORK SITE ACTIVITIES AND ASSOCIATED POLLUTANTS

General Work Activity/Products with Potential Stormwater Pollutants	Specific Work Activity/Products with Potential Stormwater Pollutants	Associated Visible Pollutant Indicator	Associated Non-Visible Potential Pollutants
Adhesives	Adhesives, glues, resins, epoxy synthetics, PVC cement Caulks, sealers, putty, sealing agents Coal tars (naphtha, pitch)	Oily sheen or other discoloration from some products	Phenolics, formaldehydes, asbestos, benzene, phenols and naphthalene
Asphalt paving/Curbs	Hot and cold mix asphalt	Oil sheen	Oil, petroleum distillates
Cleaners	Polishes (metal, ceramic, tile) Etching agents Cleaners, ammonia, lye, caustic sodas, bleaching agents and chromate salts	Discoloration/plume from some products	Metals, acidity/alkalinity, chromium
Concrete/Masonry	Cement and brick dust Colored chalks Concrete curing compounds Glazing compounds Surfaces cleaners Saw cut slurries Tile cutting	Discoloration/plume from some products	Sediments, acidity, metals, asbestos, particulates
Drywall	Saw-cutting drywall	Discoloration/plume from drywall dust	Copper, aluminum, sediments, minerals, and asbestos
Framing/Carpentry	Sawdust, particle board dust, and treated woods Saw cut slurries	Sawdust, slurry plume	BOD, formaldehyde, copper and creosote
Grading/Earthwork	Blasting Dewatering Grading activities Vegetation removal Disturbance of contaminated soil	Sediment discharge/plume, non-stormwater discharges, vegetation debris	Soil amendments (gypsum, lime), historical soil contaminants
Heating, Ventilation, Air Conditioning	Demolition or construction of air condition and heating systems	None	Asbestos, Freon
Insulation	Demolition or construction involving insulation, venting systems	None	Asbestos, aluminum, zinc
Liquid waste	Wash waters Irrigation line testing/flushing	Non-stormwater discharges, detergents, sediment, oily sheen, concrete rinse, or other plume	See non-visible pollutants listed in other categories
Painting	Paint thinners, acetone, methyl ethyl ketone, stripper paints, lacquers, varnish, enamels, turpentine, gum spirit, solvents, dyes, stripping pigments and sanding	Paint plume	VOCs, metals, phenolics and mineral spirits
Planting/Vegetation management	Vegetation control (pesticides/ herbicides) Planting Plant maintenance Vegetation removal	Mulch, sediment, vegetation	BOD, fertilizers, pesticides, herbicides, nutrients (nitrogen, phosphorous, and potassium) acidity/alkalinity, metals, aluminum sulfate, sulfur

TABLE 6.2.1. CONSTRUCTION WORK SITE ACTIVITIES AND ASSOCIATED POLLUTANTS

General Work Activity/Products with Potential Stormwater Pollutants	Specific Work Activity/Products with Potential Stormwater Pollutants	Associated Visible Pollutant Indicator	Associated Non-Visible Potential Pollutants
Plumbing	Solder (lead, tin), flux (zinc chloride), pipe fitting Galvanized metal in nails, fences, and electric wiring	None	Lead, copper, zinc and tin
Pools/fountains	Chlorinated water	Non-stormwater discharges	Chlorine or other disinfectant
Removal of existing structures	Demolition of asphalt, concrete, masonry, framing, roofing, metal structures	Sediment, other particulates	Toxics (paint strippers, solvents, adhesives), trace metals (galvanized metal, painted surfaces, preserved wood)
Roofing	Flashing Saw cut slurries (tile cutting) Shingle scrap and debris	Debris, slurry plume	Oil, petroleum distillates
Sanitary waste	Portable toilets Disturbance of existing sewer lines	Visible sanitary waste	Bacteria, BOD, pathogens
Soil preparation/ amendments	Use of soil additives/amendments	Mulch, sediment	Soil amendments
Solid waste	Litter, trash, and debris Vegetation	Plastic, paper, cigarettes, wood products, steel, vegetation waste, etc.	
Utility line testing and flushing	Hydrostatic test water Pipe flushing	Non-stormwater discharge, sediment	Chlorine
Vehicle and equipment use	Equipment operation Equipment maintenance Equipment washing Equipment fueling	Oil sheen, sediment	Total petroleum hydrocarbons, coolants, benzene and derivatives

DEWATERING AND PONDED WATER MANAGEMENT – NS-1

Application: Dewatering operations controls prevent or reduce the discharge of pollutants to the storm drain system or to watercourses from dewatering operations by using sediment controls and by testing the discharges for pollution. Dewatering and ponded water management applies to areas where storm water has collected in low spots, trenches or other depressions and needs to be removed to proceed with construction activities or for vector control. All dewatering discharge activities must be conducted in accordance with local agency (i.e., local sewerage agency or other applicable agency) permit requirements.

Construction Specifications / Installation:

- Ponded storm water shall be settled or filtered for sediment removal prior to discharge.
- Water from trench or excavation dewatering shall be tested if required by applicable permits and discharged in accordance with permit provisions.
- Water shall be clean and free of significant sediment, surfactants, or other pollutants.
- For clean ponded storm water, dewatering discharges (without state permit requirements), and authorized non-stormwater discharges, use one of the following methods for discharge disposal as appropriate for onsite drainage:
    - Reduce sediment discharge by pumping water from the top of ponded areas using a floating or raised hose.
    - Use water where possible for construction activities such as compaction and dust control and landscape irrigation. If used for these applications, ensure that the water will infiltrate and not run-off from the land to storm drain systems, to creek beds (even if dry) or to receiving waters.
    - Infiltrate to an appropriate stabilized surface area (landscaped or vegetated).
    - Discharge to an on-site temporary sediment pond.
    - Only with approval by the City of Gresham Stormwater Division Manager, discharge to the storm drain system. Water from dewatering must not contain significant sediments or other pollutants.
    - A vacuum truck may be used to remove the water and haul it to an authorized discharge location.
- If a state discharge permit is required, provide temporary onsite storage (e.g., Baker tank) of water removed from trenches and excavations until a permit to discharge is obtained.
- If a state discharge permit is obtained for discharge to a storm drain or sanitary sewer system, conduct all dewatering discharge activities in accordance with permit requirements.

Monitoring / Maintenance:

- Inspect pumps, hoses and all equipment before use. Monitor dewatering operations to ensure it does not cause offsite discharge or erosion.
- Inspect routinely, when applicable activities are under way.

PAVING OPERATIONS CONTROLS – NS-2

Application: Paving and grinding operation controls to minimize pollution of storm water runoff during paving operations.

Design Guidelines: The purpose is to prevent and reduce the discharge of pollutants by properly disposing of wastes and by implementing measures to control run-on and prevent runoff from picking up pollutants and carrying them into the storm drain system or to watercourses.

Construction Specifications / Installation:

- In order to reduce the potential for the transport of pollutants in storm water runoff from paving operations, paving shall not take place within 72 hours of a predicted significant (>0.10 inch) storm event. If paving does occur within 72 hours of a significant storm event, catch basin filters or other appropriate BMPs shall be utilized to trap hydrocarbons.
- Protect storm drain inlets near work and down gradient of work areas during saw cutting, paving, or grinding operations.
- Saw-cut slurry shall not discharge to any portion the public or private stormwater system and shall be shoveled or vacuumed and removed from site.
- Paving materials and machinery shall be stored away from storm drains and water bodies and secondary containment will be used to catch drips, leaks or spills where applicable.
- If onsite mixing is planned then an area shall be designed for conducting the mixing. This area shall be paved or made impervious (e.g., plastic or wood sheeting) and be located away from storm drain inlets or watercourses.
- Minimize overspray of tackifying emulsions or placement of other paving materials beyond the limits of the area to be paved.
- Use dry methods to clean equipment and conduct cleaning in accordance with Vehicle and Equipment Cleaning (NS-5).
- Material use and stockpiles shall be managed in accordance with BMPs EP-22 (Soil Stockpile Management), NS-8 (Material Use) and NS-9 (Stockpile Management).
- Collect and remove all broken asphalt and concrete or excess materials, recycle when feasible and dispose of materials in accordance with City, state, and federal requirements.
- Do not apply asphalt, concrete paving, seal coat, tack coat, slurry seal or fog seal if rain is expected during the application or curing period.
- Avoid transferring, loading, or unloading paving materials near storm drain inlets or watercourses. If not possible, use Storm Drain Inlet Protection (SC-8).

Monitoring / Maintenance:

- Inspect and maintain equipment and machinery routinely to minimize leaks and drips.
- Inspect inlet protection measures routinely.

TEMPORARY EQUIPMENT BRIDGE – NS-3

Application: Temporary equipment bridges are temporary structures placed across a waterway that allow vehicles to cross the waterway during construction without entering the water to prevent erosion caused by vehicles. This BMP details two types of temporary stream crossings:

1. Bridges – Appropriate for streams with high flow velocities, steep gradients and/or where temporary restrictions in channel are not allowed.
2. Culverts – Used on perennial and intermittent streams.

Design Guidelines: Temporary equipment bridges must be designed and installed properly to avoid flow restrictions, backups, washouts, and scour that could result in increased pollutant loads. Note: temporary equipment bridges may require permits from the U.S. Army Corps of Engineers (USACE) and/or the Oregon Department of State Lands (DSL), depending on the project scope and location. If a permit is not required, the City requires a written confirmation from the USACE and DSL that a permit is not required.

Materials/Equipment: Varies.

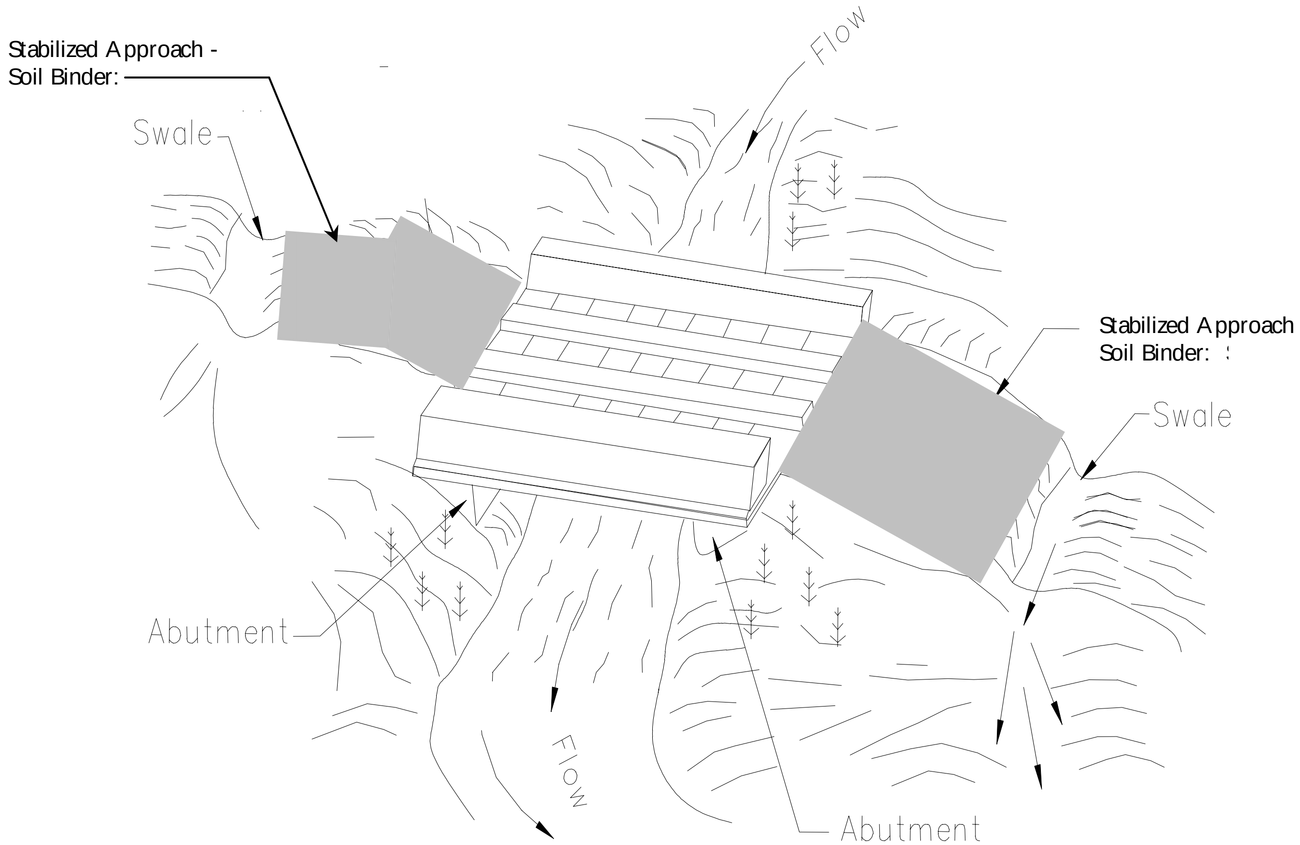
Construction Specifications/Installation:

- Location of the temporary stream crossing shall address:
  - Site selection where erosion potential is low.
  - Areas where the side slopes from pipeline right-of-way will not spill into the side slopes of the crossing.
- Design and installation requires knowledge of stream flows and soil strength. Designs shall be prepared under direction of and approved by a registered civil engineer. Both hydraulic and construction loading requirements shall be considered with the following:
  - Provide stability in the crossing and adjacent areas to withstand the design flow. The design and safety factor shall be selected based on careful evaluation of the risks due to over topping, flow backups, or washout.
  - Avoid oil or other potentially hazardous waste materials for surface treatment.
  - Provide temporary stabilization to minimize potential sedimentation from disturbed area around crossing.
- Construction consideration shall include:
  - Stabilize construction right-of-way, adjacent work area and stream bottom against erosion.
  - Schedule construction during dry periods to minimize stream disturbance.
- Specific consideration for the two types of stream crossings include:
  - Bridges: Generally more expensive to design and construct, but provide the least disturbance of the streambed and least constriction of the waterway flows.
  - Culverts: Relatively easy to construct and able to support heavy equipment loads.
- Installation may require dewatering or temporary diversion of the stream. See BMPs NS-1, Dewatering, and RC-9, In-Stream Diversion.

Monitoring/Maintenance:

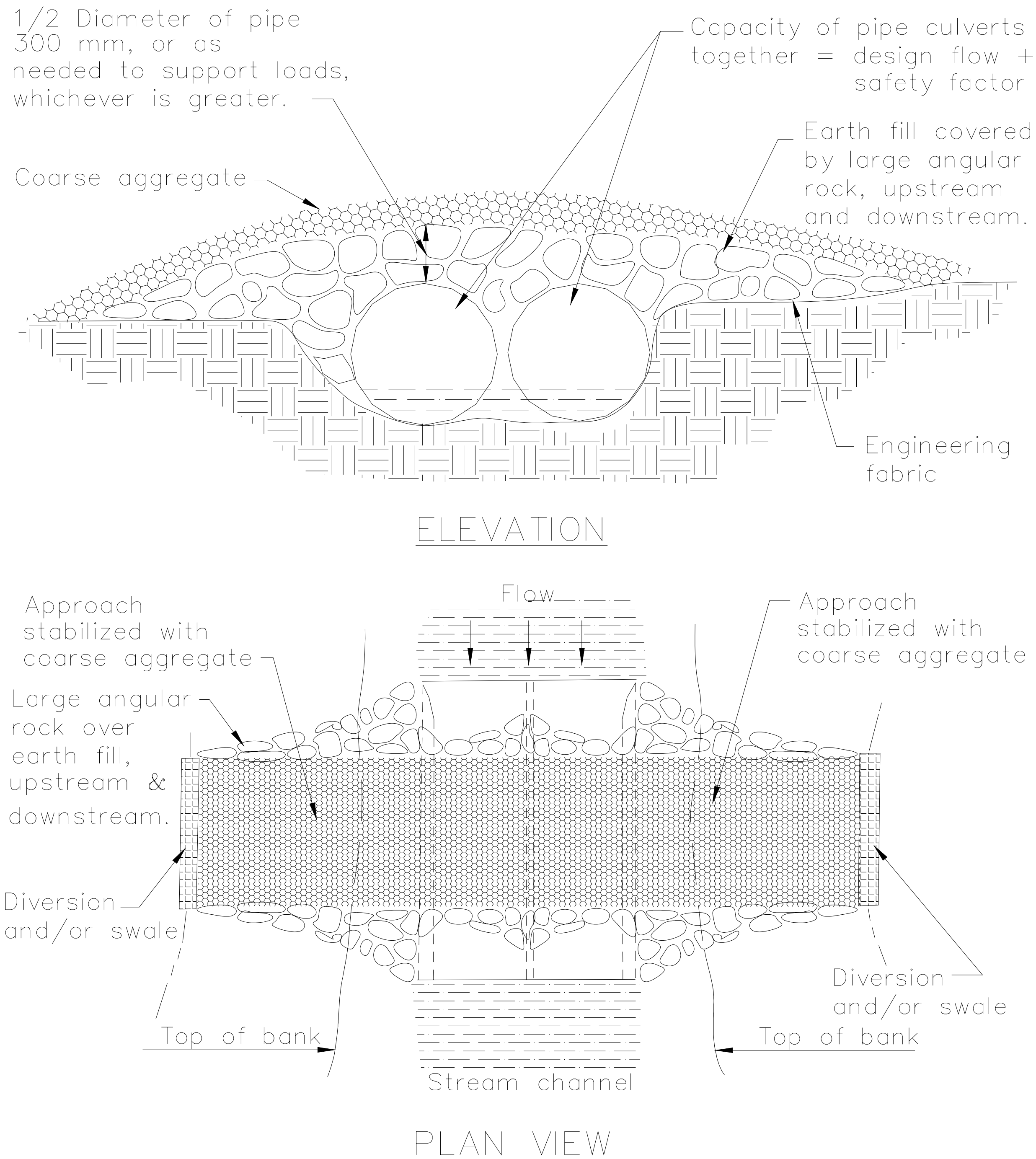
- Monitoring, at a minimum, shall occur weekly and after each significant rainfall, including:
  - Check for blockage in the channel, sediment buildup in culverts or behind ford, or trapped debris.
  - Check for erosion of abutments, channel scour, riprap displacement, or piping in the soil.
  - Check for structural weakening of the temporary crossing, such as cracks, rills, and undermining of foundations and abutments.

- Maintenance provisions shall include:
  - Periodic removal from culverts and under bridges.
  - Replacement of lost aggregate from inlets and outlets of culverts.
  - Prompt removal of temporary crossing when it is no longer needed.
  - Provide temporary or permanent stabilization of disturbed area after crossing is removed.



NOTE:
Surface flow of road diverted
by swale and/or dike.

TYPICAL BRIDGE CROSSING
NOT TO SCALE



TYPICAL CULVERT CROSSING

NOT TO SCALE

ILLICIT CONNECTION / ILLEGAL DISCHARGE – NS-4

Application: Illicit connections to the storm drain system and wastes discharged illegally are prohibited and can cause water quality impacts to receiving streams. This BMP identifies inspection and reporting procedures for contractors to identify illicit connections and illegal discharges at their job site.

Design Guidelines: The procedures and practices below are designed for construction contractors to recognize illicit connections or illegally dumped or discharged materials on a construction site and report incidents.

Monitoring / Maintenance:

Planning

- Inspect site before beginning the job for evidence of illicit connections or illegal dumping or discharges.
- Inspect site regularly during project execution for evidence of illicit connections or illegal dumping or discharges.
- Observe site perimeter for evidence or potential of illicitly discharged or illegally dumped material, which may enter the job site.
- Identified illicit connections and illegal dumpings or discharges shall be reported s to the Project Superintendent and City Inspector.

Solids. Look for debris, or rubbish piles. Solid waste dumping often occurs on roadways with light traffic loads or in areas not easily visible from the traveled way.

Liquids. Signs of illegal liquid dumping or discharge can include:

- Visible signs of staining or unusual colors to the pavement or surrounding adjacent soils.
- Pungent odors coming from the drainage systems.
- Discoloration or oily substances in the water or stains and residues detained within ditches, channels or drain boxes.
- Abnormal water flow during the dry weather season.

Urban Areas. Evidence of illicit connections or illegal discharges is typically detected at storm drain outfall locations or at manholes. Signs of an illicit connection or illegal discharge can include:

- Abnormal water flow during the dry weather season.
- Unusual flows in sub-drain systems used for dewatering.
- Pungent odors coming from the drainage systems.
- Discoloration or oily substances in the water or stains and residues detained within ditches, channels or drain boxes.
- Excessive sediment deposits, particularly adjacent to or near active off-site construction projects.

Rural Areas. Illicit connections or illegal discharges involving irrigation drainage ditches are detected by visual inspections. Signs of an illicit discharge can include:

- Abnormal water flow during the dry weather season.
- Non-standard junction structures.
- Broken concrete or other disturbances at or near junction structures.

Reporting

- Notify the Project Superintendent and City Inspector of any illicit connections and illegal dumping or discharge incidents at the time of discovery.

VEHICLE AND EQUIPMENT CLEANING – NS-5

Application: Vehicle and equipment cleaning controls are procedures and practices to minimize or eliminate the discharge of pollutants from vehicle and equipment cleaning to the storm drain system or to watercourses.

Construction Specifications / Installation:

- Only vehicle wheel washing is allowed on construction sites to prevent offsite sediment tracking.
- Concrete truck and equipment washing shall follow the specifications outlined in BMP NS-14.
- Vehicles and equipment shall be washed off site at a controlled wash facility.
- Only in emergency situations is onsite vehicle washing allowed. Use "dry cleaning methods" such as wiping down vehicles rather than water washing vehicles on site. If cleaning must be conducted on site, it shall be conducted in a dedicated area with the following characteristics:
    - Located away from storm drain inlets, drainage facilities, or watercourses. At no time is wash water allowed to discharge into any portion of a public or private stormwater system.
    - Paved with concrete or asphalt, or stabilized with an aggregate base.
    - Bermed to contain wash water and to prevent run-on and runoff.
    - Configure wash area with a sump to allow collection and disposal of wash water by vactor truck.
    - Discharges of wash water to a sanitary or process waste sewer must be approved by the City Wastewater Services Division.
- When cleaning vehicles or equipment with water:
    - Use as little water as possible. High pressure sprayers may use less water than a hose, and shall be considered.
    - Use positive shutoff valve to minimize water usage.
    - Do not use solvents or detergents to clean vehicles or equipment on site.
    - Do not permit steam cleaning on site.

Monitoring / Maintenance:

- Inspect and clean work areas regularly to limit wind blow debris and pollutants transported by storm water.

VEHICLE AND EQUIPMENT FUELING, MAINTENANCE, AND STORAGE – NS-6

Application: Vehicle and equipment fueling, maintenance, and storage controls are procedures and practices to minimize or eliminate the discharge of fuel and lubricant spills and leaks to the storm drain system or to watercourses.

Design Guidelines: Vehicles and heavy machinery are a potential source of pollutants such as petroleum products, antifreeze, and exhaust and waste oil containing heavy metals. Pollutants may enter stormwater runoff by means of direct contact with machine ports and by contact with spills on surfaces and the ground. Use specifications to help prevent contact of these potential pollutants with stormwater and ground surfaces.

Construction Specifications/Installation:

Fueling. On site vehicle and equipment fueling shall only be used where it is impractical to send vehicles and equipment offsite for fueling. When fueling must occur on site, the contractor shall select and designate an area to be used, subject to approval. Vehicle and equipment fueling (including fueling of handheld equipment) shall be conducted in accordance with the following:

- Away from storm drain inlets, drainage facilities, or watercourses.
- On a paved surface where practical, and within a berm to prevent run-on, runoff, and to contain spills.
- Store portable fuel containers for hand-held equipment in a tub or equivalent device to avoid spills/leaks.
- Use secondary containment techniques for fueling of handheld or portable equipment, such as drain pans or drop cloths to catch spills or leaks.
- All fueling shall be conducted with the fueling operator in attendance at all times.
- Use vapor recovery nozzles to help control drips and reduce air pollution and nozzles equipped with automatic shutoff features to prevent overtopping fuel tank.
- Signage that fuel tanks shall not be "topped off."
- An adequate supply of spill clean up materials shall be readily accessible to all fueling activities.

Maintenance. Maintenance of large equipment shall be conducted within designated maintenance yards in order to enable careful management. During minor routine maintenance, drip pans shall be placed under vehicles and equipment. All on site vehicles shall be monitored for leaks and shall receive preventive maintenance to reduce leakage.

Only necessary maintenance required for the proper functioning of handheld equipment and portable generators/compressors is allowed onsite. Drop clothes, trays or an equivalent method shall be used underneath handheld and portable equipment to avoid leaking fluids, fuels, oils, or grease onto the ground. Do not overspray aerosols to the ground or other rain-exposed surfaces. Clean up spills immediately and dispose of waste properly.

Fuel and Vehicle Storage. Fuel storage shall be conducted in accordance with applicable local, state, and federal regulations and in accordance with BMP NS-12, Hazardous Materials and Waste Management. Vehicles and equipment shall be stored in designated, bermed vehicle storage areas (such as dedicated storage areas or fueling and maintenance areas) when possible, or off of paved areas to the extent practical. During long periods (typically more than one month) of storage, and when otherwise necessary drip pans shall be placed under vehicles and equipment that are prone to leakage. Plastic tarps shall be placed over exposed equipment when not in use for long periods (>3 months) to prevent contact with stormwater. All on site vehicles shall be monitored for leaks and shall receive preventive maintenance to reduce leakage.

Monitoring / Maintenance:

- Check to ensure adequate supply of spill cleanup materials is available.
- Perform routine inspections of designated maintenance, cleaning, and fueling areas.
- Report all spills immediately to the project Superintendent. A spill of any size that discharges directly to a stream or any spill over 42 gallons to the ground, must be reported to DEQ immediately.
- Service sumps regularly.

MATERIAL DELIVERY AND STORAGE CONTROLS – NS-7

Application: Material delivery and storage controls are procedures and practices for the delivery and storage of materials in a manner that minimizes or eliminates the discharge of these materials to the storm drain system or to watercourses.

Design Guidelines: Many materials used in construction can contribute pollutants to storm water runoff. Examples of such materials include soil, vehicle fuels, oils, antifreeze, paints/coatings, pressure treated lumber, dry wall, fertilizers, pesticides, and herbicides.

Construction Specifications/Installation:

- All construction materials shall be delivered to and stored in designated areas or designated staging areas at the construction site.
- Material storage areas shall be placed near construction site entrances to the extent practicable, away from storm drain inlets, culverts and surface waterbodies.
- Designated storage areas shall be kept clean, well organized, and litter-free.
- Any materials being stored that could release pollutants by wind or runoff transport shall be protected by overhead cover, secondary containment, tarpaulins, visqueen/plastic sheeting or other appropriate method prior to rainfall or periods of high wind. Where feasible, store materials indoors (e.g., container storage or garages/buildings under construction, where work is being conducted).
- Any chemicals, drums or bagged materials not stored in a covered location, shall be stored on pallets and in secondary containment.
- Secondary containment shall be provided for liquids.
- Secondary containment areas shall be covered to prevent accumulation of rainwater.
- Construction materials shall be stored in a manner to prevent or minimize contact with storm water.
- The main loading, unloading, and access areas shall be located away from storm drain inlets and channels.
- Enclosures or flow barriers (berms) shall be constructed around designated storage areas to prevent storm water flows from entering storm drains or receiving waters and to control the discharge of sediments and other pollutants.
- Deliveries shall be scheduled in a manner that reduces the time for onsite storage of potentially polluting materials prior to use and minimize the number of material drop locations.
- Fuels shall be stored in accordance with BMP NS-6, Vehicle and Equipment Fueling, Maintenance, and Storage.
- Hazardous materials shall be stored in accordance with BMP NS-12, Hazardous Material and Waste Management.

Monitoring/Maintenance:

Inspect material storage areas routinely for compliance with the above practices.

MATERIAL USE – NS-8

Application: Material use controls are procedures and practices for use of construction materials in a manner that minimizes or eliminates the discharge of these materials to the storm drain system or to watercourses.

Design Guidelines: Apply this BMP when the following materials are used or prepared on site: pesticides and herbicides; fertilizers and soil amendments; detergents; petroleum products such as fuel, oil, and grease; asphalt and other concrete components; plaster; hazardous chemicals such as acids, lime, glues, adhesives, paints, solvents, and curing compounds; mastic, pipe wrap, primers, and paint; concrete compounds; welding material; and other materials that may be detrimental if released to the environment.

Construction Specifications / Installation:

- Order and store only materials that are required for site needs.
- Materials shall be delivered at such time to minimize onsite storage.
- Materials shall be used in accordance with manufacturer directions and in a manner to reduce or eliminate release of pollutants
- An accurate, up-to-date inventory of materials delivered and stored on-site shall be kept by each contractor.
- Reduce or eliminate use of hazardous materials on site when practical. Use safer, recycled and/or less hazardous products when practical.
- Use materials only where and when needed to complete the construction activity.
- Recycle residual paints, solvents, non-treated lumber, and other materials.
- Do not remove the original product label; it contains important safety and disposal information.
- Use the entire product before disposing of the container.
- Keep an ample supply of spill clean up material near use areas. Instruct employees in spill clean up procedures.
- Avoid exposing applied materials to rainfall unless sufficient time has been allowed for them to dry or cure.

Monitoring / Maintenance:

- Spot check employees and subcontractors monthly throughout the job to ensure appropriate practices are being employed.

NON-SOIL STOCKPILE MANAGEMENT – NS-9

Application: Non-soil stockpile management practices are designed to reduce or eliminate air and storm water pollution from stockpiles of sand, and paving materials, such as Portland cement concrete (PCC) rubble, asphalt concrete (AC), asphalt concrete rubble, aggregate base, aggregate sub-base or pre-mixed aggregate, asphalt binder (so called "cold mix" asphalt), and pressure treated wood.

For soil stockpile management see EP-22, and for topsoil stockpile management, see EP-4.

Construction Specifications / Installation:

All Stockpiles

- Locate stockpiles a minimum of 50 feet away from inlets, drainage courses, or water bodies.
- Keep stockpiles organized and surrounding areas clean.
- Protect storm drain inlets, drainage courses, and receiving waters from non-soil stockpiles, using drain inlet protection and perimeter sediment controls as appropriate.
- Implement dust control practices as appropriate to prevent wind erosion of stockpiled material.
- Temporary non-soil stockpiles not removed or used by the end of one workday must be managed in accordance with this BMP and in all cases protected prior to rainfall.

Stockpiles of Portland Cement, Sand, Mulch, Concrete Rubble, Asphalt Concrete, Asphalt Concrete Rubble, Aggregate Base, or Aggregate Sub-Base

- Protect non-soil stockpiles with a perimeter sediment control, such as a berm, sediment fence, fiber rolls, or sand/gravel bags year round.
- Non-soil stockpiles shall additionally be covered or stabilized between October 1 and May 31, and as necessary during significant forecasted storm events (> 0.25 inch), prolonged periods of rain, and to protect from wind erosion.

Stockpiles of "Cold Mix" or Other Pollutants Easily Transported in Storm Water (Cement, Lime, and Other Caustic Amendments)

- Stockpiles shall be placed on plastic or comparable material at all times.
- Stockpiles shall be covered between October 1 and May 31 with 6-millimeter plastic or comparable material and prior to the onset of significant rain (> 0.1 inch).

Bagged Materials

- Bagged materials shall be placed on pallets at all times and under cover (e.g., plastic sheeting, indoors) between October 1 and May 31, and prior to the onset of significant rain (>0.10 inch).

Stockpiles/Storage of Pressure Treated Wood with Copper, Chromium, and Arsenic or Ammoniacal Copper, Zinc, and Arsenate

- Stockpiles of treated wood shall be covered with plastic or comparable material between October 1 and May 31, and prior to the onset of significant rain (>0.25 inch).

Monitoring / Maintenance:

- Inspect non-soil stockpiles regularly and repair and/or replace covers, and perimeter controls, as needed.

SPILL PREVENTION AND CONTROL PROCEDURES – NS-10

Application: Spill prevention and control measures are procedures and practices to prevent and control spills in a manner that minimizes or eliminates the discharge of spilled material to the storm drain system or to watercourses.

Design Guidelines: Spills and leaks can be significant sources of stormwater pollutants and are, in most cases, avoidable.

Construction Specifications / Installation:

- The contractor shall prepare a site/project specific spill response plan that identifies the type and location of products or wastes on the site with spill potential, the location of spill cleanup materials, storm drains or sensitive areas that require immediate response, personnel responsible for spill response and notifications, and spill cleanup procedures.
- Heavy equipment (e.g., bulldozers and other grading equipment) and vehicles shall be inspected daily for leaks and shall be repaired as necessary. Use secondary containment and drip pans for vehicle fueling, maintenance, and storage (see BMP NS-6, Vehicle and Equipment Fueling, Maintenance, and Storage).
- Despite precautions, spills may still occur at the site. Spills (liquid or dry materials) shall not be cleaned up by hosing off the area. In the event that a spill does occur, the spill shall be controlled as follows:
    - Any fuel products, lubricating fluids, grease or other products and/or waste released from vehicles, equipment, or operations shall be collected and disposed of in accordance with City, state, and federal regulations;
    - If a spill occurs during a rain event, the area shall be contained and covered immediately. If the spill is a liquid, absorbent material also shall be used. The spill shall be cleaned up at the cessation of rain; and
    - Spill cleanup materials shall be stored near potential spill areas (e.g., painting, vehicle maintenance areas).

Reportable Spill Quantities. Any spill (hazardous or non-hazardous) over 42 gallons or any spill directly discharging to a stream or waterway must be reported. The project Superintendent will notify the Oregon Emergency Response System (OERS), Oregon DEQ, and the City Inspector. It is the project Superintendent's responsibility to have all of the emergency phone numbers at the construction site.

For spills of federal Reportable Quantity (as established under 40 CFR Parts 110, 117, or 302), the project Superintendent will notify the National Response Center by telephone at (800) 424-8802 within 24 hours. Within 14 days, the project Superintendent will submit a written description of the release to EPA Region 10, including the date and circumstances of the incident and steps taken to prevent another release.

Minor Spills. Minor spills typically involve small quantities of oil, gasoline, paint, etc. that can be controlled by the first responder at the discovery of the spill. Control of minor shall include:

- Containing the spill immediately.
- Recovering spilled materials (if possible).
- Cleaning the contaminated area and dispose of contaminated materials.

Medium-Sized Spills. Medium-sized spills still can be controlled by the first responder, along with the aid of other personnel such as laborers, foremen, etc. This response may require the cessation of other activities. Spills shall be cleaned up immediately, as follows:

- Notify the project foreman immediately. The foreman/superintendent is responsible for any necessary notifications (fire department, etc.).
- Contain the spread of the spill (using sand bags or other barriers) immediately.
- If the spill has occurred on a paved or impermeable surface, clean it up using dry methods (absorbent materials, cat litter, and/or rags). Contain the spill by encircling it with absorbent materials.
- If the spill has occurred on an unpaved or permeable surface, immediately contain the spill by constructing an earthen dike. Dig up and properly dispose of contaminated soil.
- If the spill has occurred during a rain event, cover and contain the spill area. Absorbent material also shall be placed if the spill is liquid.
- **Significant/Hazardous Spills.** For large spills or spills involving hazardous materials that cannot be controlled by project personnel, the following steps shall be taken:
- The Foreman shall notify the project Superintendent immediately and follow up with a written incident report.
- The project Superintendent will immediately notify local emergency response personnel by dialing 911
- Retain the services of a Spill Cleanup Contractor or HazMat Team immediately. Construction personnel shall not attempt to clean up the spill until the appropriate and qualified staff has arrived at the site.
- Other agencies that may need to be contacted include the Gresham Fire Department, Oregon Department of Transportation, etc.

Monitoring/Maintenance:

- Inspect work and material storage areas routinely for adequate containment to avoid uncontrolled releases.

SOLID WASTE MANAGEMENT – NS-11

Application: Solid waste management controls are procedures and practices to minimize or eliminate the discharge of pollutants to the storm drain system or to watercourses as a result of the creation, stockpiling, and removal of construction site wastes.

Construction Specifications/Installation:

- Solid wastes shall be cleaned up daily. Paved areas shall be swept, not washed. Use of water for cleaning is prohibited unless approved on a project specific basis by the owner. If approved, wash water shall not be discharged to the storm sewer and shall be collected, contained and disposed of appropriately (see bullet below regarding liquid wastes).
- There shall be designated temporary waste storage areas on the site.
- Designated waste storage areas shall be contained within earthen berms or provided with other perimeter protection to prevent run-on to and runoff from the area.
- Non-hazardous construction wastes (e.g., vegetation, trash, and construction debris) shall be collected daily and before storm events and deposited at the designated waste storage areas.
- When practical, wastes shall be stored within covered, water-tight dumpsters and/or containers that prevent exposure to rain and prevent loss of wastes when it is windy.
- Dumpsters shall not be hosed out on the construction site. Any required dumpster cleaning will be done off-site by the trash hauling contractor.
- Any waste containers constructed on-site (not prefabricated) shall be inspected prior to use and inspected regularly to verify integrity.
- Any wastes stored in open containers or waste piles shall be covered prior to significant forecasted rain (0.25 inch).
- All waste materials shall be removed from the storage areas on a weekly basis, or more frequently if capacity is reached, and disposed or recycled in accordance with all City, state, and federal regulations.
- Any solid waste that accumulates at erosion and sediment control devices shall be removed daily.
- Liquid wastes shall be managed in accordance with the BMP NS-16, Liquid Waste Management.

HAZARDOUS MATERIALS AND WASTE MANAGEMENT – NS-12

Application: Hazardous materials and waste management controls are procedures and practices to minimize or eliminate the discharge of pollutants from construction site hazardous waste to the storm drain system or to watercourses.

Construction Specifications/Installation:

Hazardous Materials

- Storage of hazardous materials on site shall be minimized. Any hazardous materials used during construction shall be containerized and kept closed during work activities.
- Hazardous material storage shall conform to all applicable local, state and federal requirements.
- Hazardous materials shall be stored in sealed containers within an enclosed container or a bermed and permanently covered storage area. Lids alone shall not be considered adequate cover.
- Dedicated areas of the construction site shall be designated for hazardous material delivery and storage. Designated storage areas will be placed away from drain inlets, culverts, and surface waterbodies, preferably near construction site entrances.
- Designated storage areas shall be kept clean and well organized.
- The following types of materials shall be stored in accordance with these provisions: fertilizers, herbicides, pesticides, detergents, oil, grease, glues, paints, solvents, curing compounds materials, and other similar materials that could be considered potential pollutants in storm water discharge.
- Fuel shall be stored and managed in accordance with BMP NS-6, Vehicle and Equipment Fueling, Maintenance, and Storage.
- Regular inspections of storage areas shall be conducted to monitor inventory and check for leaking containers.

Hazardous Wastes

- Hazardous wastes and containers shall be placed in a designated hazardous waste storage area that is permanently covered and has an impermeable bottom surface surrounded by secondary containment to minimize the mixing of wastes with storm water and to prevent the direct release of liquid waste to storm water. Temporary storage and removal of hazardous wastes from the site shall be in accordance with all applicable state and federal laws.
- Wastes shall be segregated and recycled where feasible (e.g., paints, solvents, used oil, batteries, anti-freeze). Wastes shall not be mixed since this can cause potentially dangerous chemical reactions, make recycling impossible and complicate disposal.
- Covered waste bins shall be designated for the disposal of all empty hazardous waste product (e.g., paints, solvents, glues, petroleum products, exterior finishes, pesticides, fertilizers, etc.) containers. The original product label shall not be removed as it contains important safety and disposal information.

- Toxic wastes and chemicals shall not be disposed of in dumpsters designated for construction debris.
- If any asbestos is discovered in the demolished materials, asbestos removal and disposal shall be performed by a licensed contractor or licensed subcontractor trained in asbestos removal. All removal and disposal shall be done in accordance with state and federal regulations. Any asbestos wastes stored on-site prior to removal shall be stored within dumpsters (roll-offs) covered with tarps or other appropriate method to prevent contact with rain and minimize exposure to wind.
- Employees and subcontractors shall be trained on proper storage practices.

CONTAMINATED SOIL MANAGEMENT – NS-13

Application: Contaminated soil management controls are procedures and practices to minimize or eliminate the discharge of pollutants to the storm drain system or to watercourses as a result of construction activity in or near contaminated soils.

Design Guidelines: A number of practices occurring during construction may lead to contamination of soils. For example, leaks and spills of petroleum products from leaking vehicles and routine vehicle and equipment maintenance can cause soil contamination.

Construction Specifications/Installation:

- All soils contaminated by construction activities must be removed and disposed of per state disposal requirements.
- In the event that soil contamination is suspected but not confirmed, the contractor will obtain samples for analysis by a certified analytical laboratory.
- Decisions regarding soil removal and disposal will be based on the results of the analysis.
- No soils contaminated by construction activities shall be buried or otherwise disposed of on site.
- Areas of historic contamination shall be managed in accordance with approved remediation work plans or equivalent documents.
- Containment shall be provided around areas of historic contamination or soils contaminated by construction activities (not yet removed) to eliminate run-on to and off-site discharges from these areas and associated non-visible pollutant monitoring requirements. Containment zones shall consist of earthen berms, excavated diversion channels, or over excavation in the area of concern to create a "bath-tub."
- Contaminated soils may be temporarily stored in accordance with applicable City, state, and federal regulations. At a minimum soils shall be stored on a contained, impervious surface and be covered prior to proper disposal.

CONCRETE MANAGEMENT – NS-14

Application: Concrete management controls are procedures and practices to minimize or eliminate the discharge of concrete residuals and waste to the storm drain system or to watercourses.

Design Guidelines: Concrete trucks and equipment will be washed-out on site utilizing a concrete washout to collect all wash water and concrete waste. The washout area will be located away from storm drains, open ditches or water bodies. Signs will be posted throughout the jobsite, directing crews and concrete trucks to concrete washouts. Upon completion of the concrete work, the contractor shall break up, remove, and haul away or reuse on site solid concrete that has accumulated in the washout.

Construction Specifications/Installation:

Material Use

- A washout shall be an excavated depression with dimensions large enough to prevent concrete slurry overflow. All concrete washing activities shall be done so that slurry is collected in the washout.
- Install storm drain protection at any down-gradient inlets that may be impacted by the activity. See BMP SC-8, Storm Drain Inlet Protection.
- Do not place concrete during rain (precipitation that is sufficient to cause local runoff) or within 18 hours of forecasted rain.
- Place stoppers on concrete truck chutes during travel onsite to manage potential dribbling of concrete material.
- Minimize amount of curing compound and form oil used and do not overspray onto a non-target surface.
- When sandblasting, use shrouds where necessary to contain waste from sandblasting. Conduct work in accordance with applicable air quality standards. Collected debris for proper disposal as soon as possible, and prior to rain events.
- Minimize the amount of water used during coring/drilling or saw cutting. During wet coring or saw cutting, use a shovel or wet vacuum to lift the cooling water/slurry from the pavement. Additionally, if wet vacuuming is not adequate to capture wastewater from the activity, sand bag barriers or other containment shall be used.
- If concrete residue remains after drying, the area shall be swept up and residue removed to avoid contact with storm water or entering a storm drain or water body via the wind.
- The sweepings shall be collected and returned to the aggregate stockpile or disposed in the trash and not washed into the street or storm drain.
- Washing of fresh concrete shall be avoided, unless runoff can be drained to a bermed or level area, away from storm drain inlets and channels.
- Acid washing of concrete shall be minimized. Where required, acid wash shall be directed into a collection area lined with visqueen. Residuals shall be collected and properly disposed of as hazardous waste.

- Handling of wet concrete, such as moving a pumper chute or transporting material in a wheelbarrow from the delivery truck, must be performed in a controlled manner to prevent drips and spills outside the target pour area. Minimize water use.
- Concrete drips, spills, over pours, and equipment rinse water landing on rain-exposed outside of any BMP device must be collected and have the surface cleaned and waste disposed of properly prior to the end of the workday or before the next rain event. Concrete-laden equipment implements (e.g., crane buckets) must be stored on top of heavy mil plastic until dry. Used forms that are not immediately placed into a haul truck when removed from foundations must also be temporarily staged over plastic sheeting or an equivalent until rinsed, wiped, or dried or until hauled off-site.

Waste Management

- Do not discharge concrete residue or particulate matter into a storm drain inlet or watercourse.
- Excess concrete shall not be dumped on-site.
- The following options shall be used for concrete truck chute and/or pump and hose washout:
    - **Concrete Washouts:** Washout stations can be a plastic lined temporary pit or bermed area designed with sufficient volume to completely contain all liquid and waste concrete materials plus enough capacity for rainwater. The designated area shall be located away from storm drain inlets, or watercourses. New washouts shall be constructed as needed to provide sufficient washout capacity on-site. Wastes other than concrete (i.e., trash, paint wastes etc.) shall not be disposed of in the washout.
    - **Washout in Trench:** Manually rinse the concrete truck chute into the trench itself.
    - **Bucket Washout:** Manually rinse the chute into a wheelbarrow, plastic bucket or pail, and then empty the bucket into the concrete truck barrel or on top of the placed concrete.

Monitoring / Maintenance:

- Responsible personnel shall ensure that all concrete truck drivers are instructed about project practices when the trucks arrive on site.
- Clean out designated washout areas as needed or at a minimum when the washout is 75% full to maintain sufficient capacity throughout the project duration.
- Any designated onsite washout areas shall be cleaned out and all debris removed upon project completion. Dispose of concrete waste according to BMP NS-11, Solid Waste Management.
- Inspect routinely, when applicable activities are underway to ensure that concrete washout does not overflow and that freeboard is adequate to contain concrete and rain.

SANITARY WASTE MANAGEMENT – NS-15

Application: Sanitary and septic waste management controls are procedures and practices to minimize or eliminate the discharge of construction site sanitary/septic waste materials to the storm drain system or to watercourses.

Construction Specifications/Installation:

- All sanitary wastes shall be collected and managed through the use of portable toilet facilities.
- Portable toilets shall be placed on a level surface and to the extent practical, a safe distance away from paved areas and away from storm drains.
- Portable toilets shall be provided with secondary containment.
- If placed in an area of high winds, portable toilets shall be secured to the ground to prevent blowing over.
- Portable toilets shall be transported to and from the construction site by a licensed contractor.
- No sanitary wastes shall be disposed of on site (e.g., to on-site storm drains, burial).
- Care shall be taken during pump-out to avoid spillage. If spillage occurs, it shall be cleaned up immediately.

LIQUID WASTE MANAGEMENT – NS-16

Application: Liquid waste management is applicable to construction projects that generate non-hazardous by products, residuals, or wastes, including but not limited to drilling slurries and fluids, grease-free and oil-free wastewater and rinse water, dredging spoils, or other non-stormwater liquid discharges not permitted by separate permits.

Design Guidelines: Liquid waste management is applicable to construction projects that generate any of the following non-hazardous by products, residuals, or wastes, as noted above.

Separate BMPs shall also be referenced for the following on-site liquid wastes:

- NS-1, dewatering operations.
- NS-12, liquid hazardous wastes.
- NS-14, concrete slurry residue.

Construction Specifications/Installation:

- Vehicle and equipment cleaning using water is discouraged on site. Refer to BMP NS-5.
- Drilling residue and drilling fluids shall be disposed of in accordance with appropriate requirements at an approved disposal site.
- Wastes generated as part of an operational procedure, such as water-laden dredged material and drilling mud, shall be contained and not allowed to flow into storm drain system, drainage channels, or receiving waters.
- Contain non-hazardous liquid wastes in a controlled area, such as a lined holding pit, lined sediment basin, roll-off bin, or portable tank.
- Containment devices must be of sufficient quantity or volume to completely contain the liquid wastes generated and any addition volume based on anticipated rainfall.
- Do not locate containment areas or devices where accidental release of the contained liquid can threaten health or safety, or discharge to watercourses, storm drain system, or to a receiving water.
- Capture all liquid wastes running off a surface that has the potential to affect the storm drainage system. Examples are: wash water and rinse water from cleaning walls or pavement.
- If the liquid waste is sediment laden, use a sediment trap or capture in a containment device and allow sediment to settle.
- Disposal of liquid wastes are subject to specific laws and regulations, or to requirements of other permits secured for the construction project.

Monitoring/Maintenance:

- Remove deposited solids from containment areas and containment systems as needed, and at the completion of the project.
- Inspect containment areas and containment systems routinely for damage, and repair as needed.

TRAINING AND SIGNAGE – NS-17

Application: Training of contractor and subcontractor personnel is an essential component to good stormwater management. Trained site personnel are more capable of managing materials to prevent spills, and implement control practices efficiently and correctly. This BMP presents general guidelines for personnel training including recommended signage requirements to inform personnel of stormwater-related information relevant to the site.

Design Guidelines: Personnel at all levels shall be trained in the components and goals of the permit.

Construction Specifications/ Installation:

The measures below shall be followed to ensure the Plan is effectively implemented, BMP inspections are performed, BMP maintenance and repair are performed, and appropriate records are prepared and retained:

- Before beginning construction activities and periodically during construction, on-site personnel shall receive training for implementation of the Plan; performance of BMP inspection, maintenance, and repair; record keeping; and prevention of and response to non-stormwater discharges. Training shall be documented by the contractor.
- Training for individuals responsible for overseeing, revising, and amending the Plan shall be documented.
- All employees and contractors working onsite shall be trained by staff familiar with the Plan requirements before they shall be permitted to work at the site. Contractors shall be responsible for informing their subcontractors about EPSCP requirements.
- BMP drawings, trade water quality guidelines, fact sheets, or other specifications shall be copied and distributed to contractors and site personnel engaged in the activity in question and/or installation/maintenance of BMPs.
- The Plan, construction plans, public works standards, and Manual shall be kept on-site. Stormwater pollution prevention information shall be posted on-site, such as:
    - Job Site Clean-Up Required Everyday.
    - Directions to and identification of concrete and paint wash outs.
    - Erosion Prevention and Sediment Control Plan is in effect, and its location.

APPENDIX A

Excerpts from the Gresham Development Code that Pertain to Erosion Prevention and Sediment Control

The authority of the city to regulate erosion prevention and sediment control is set forth in the City of Gresham Development Code (GDC; January 2004) at the time of this writing. The following sections are especially pertinent and are listed here for convenience only. It is the responsibility of the developer/site manager to ensure compliance with the most recent city code.

Section 9.0500 Grading and Drainage and Stormwater Quality Control Requirements

9.0514 Erosion Prevention and Sediment Control Measures During Construction

Unless otherwise approved, the following standards are adopted as minimum requirements for the purposes of minimizing or preventing erosion. The final program for soil stabilization may vary as site conditions and development warrant. These minimum guidelines are not intended to resolve all project soil erosion conditions. The applicant for a development permit is ultimately responsible for containing all soil on the project site and must recognize the potential for changing or unexpected site and weather conditions. The applicant for a development permit or, in the case of a land division, before the Notice to Proceed is issued, shall submit an erosion prevention and sediment control plan as part of their application utilizing appropriate best management practices (BMPs), per the Erosion Prevention and Sediment Control Manual (EPSC Manual). If necessary to meet the intent of this section, the applicant shall update or modify the erosion prevention and sediment control measures, per the EPSC Manual, as such conditions render existing measures ineffective.

(A) The plans and specifications will demonstrate the minimization of stripping vegetation on the project site.

(B) If top soil is to remain stockpiled during wet weather, seeding, mulching or other stabilization measures are required.

(C) All areas which will, by necessity, be left bare after October 1 shall be seeded and mulched to a cover crop (e.g., cereal rye, annual rye grass, perennial rye grass). Mulching and mulching with landscaping may be a viable alternative to seeding. Seed and mulch shall be applied with a tackifier in areas in excess of 10% slope. If, by the date set forth in the EPSC Manual, seeding has not established itself to the point of being an effective erosion control measure, additional measures may be required. Regular inspection and maintenance, as necessary, is required to maintain the effectiveness of the erosion prevention and sediment control measures.

(D) Means shall be devised to prevent sediment laden water from entering the public storm sewer system or natural watercourses. Use of approved filtration measures to prevent sediment transport from the site will be required.

(E) In areas of concentrated flow, temporary diversion berms, chutes or downpipes and down drains sized for a two-year storm may be required for projects left incomplete during the winter months. Temporary check dams may be required for channels carrying sufficient amounts of water to cause channel scouring and erosion.

(F) Temporary check dams may be required for channels carrying sufficient amounts of water to cause channel scouring and erosion.

(G) All erosion prevention and sediment control measures shall be maintained, including replacement and repair as needed, as required by the EPSC Manual.

9.0515 Establishing Protective Vegetative Cover upon Completion of Final Grading

(A) Vegetation is to be established as soon as practicable after completion of grading to minimize erosion. Prior to final project acceptance, the site shall be permanently stabilized with seed and mulch, or permanent landscaping. Seed and mulch shall be applied with a tackifier in areas in excess of 10% slope. In cases of a land division, temporary groundcover will be accepted on each lot where home construction will begin within 30 days of project completion.

(B) All swales and channels shall be permanently stabilized prior to use as specified in the EPSC Manual.

(C) Erosion control measures shall be continued after construction until the vegetative ground cover for the site is established and functioning such that erosion has ceased.

(D) The developer will be responsible for all erosion prevention and sediment control for individual lots until ownership has changed.

(E) In cases with developments with 1200-C permits, the developer is responsible for erosion prevention and sediment control until the 1200-C permit is terminated by the state.

(F) Temporary sediment control measures shall be removed by the developer when permanent stabilization or landscaping has been installed and is functioning.

Section 5.0200 Hillside Physical Constraint Overlay District

5.0223 Minimizing Site Disturbance

The applicant shall show all site grading, clearing and other site disturbance including that proposed for rights-of-way, utilities, buildable areas and driveways, as described in Section 5.0210(D), Preliminary Grading Plan.

(A) No more than 35% of the total site of the area exhibiting slopes of 15% or greater (before development), shall be graded, cleared or otherwise disturbed. Except that one additional percentage of land may be disturbed for each percentage of land dedicated to open space above the minimum required in Section 6.0324 (i.e., 40% [35%+5%] of the total site over 15% slope may be disturbed if a minimum of 30% [25%+5%] open space is dedicated). For individual single-family dwelling building permits, see Section 5.0202(B)(2)(a).

In order to meet this requirement, applicants are encouraged to pursue innovative site design techniques such as:

- Limiting grading on building lots only to that area needed for driveways and building pads;
- Limiting the total area of the site dedicated to roadways while maintaining adequate connectivity and providing for adequate emergency access consistent with the roadway standards;
- Locating roads on less steeply sloped areas to minimize the width of graded areas needed for roads;
- Designing and locating structures so that they fit into the contour of the hillside rather than altering the hillside to fit the structure;
- Using retaining structures as an alternative to banks of cuts and fills;
- Building designs, which require less grading, such as split-level and stair-stepping foundations and the use of piers;

- Placing structures as close as possible to the street so as to minimize driveway construction in the sloped areas; and
- Focusing development on slopes less than 15%.

(B) Hillside Grading and Drainage Control

All development on lands within the HPCD shall provide construction plans that conform to the following items:

(1) All grading, retaining wall design, drainage, and erosion control for development on HPCD lands shall be designed by a Registered Civil Engineer in accordance with the recommendations and guidelines provided in the Soils and Geology Report, as approved by the Manager. All cuts, grading or fills shall conform to Chapter 70 of the Uniform Building Code. Erosion control measures shall conform to Section 9.0514.

(2) For developments other than single family homes on individual lots, all grading, drainage improvements, or other land disturbances on slopes of 15% or greater, shall only occur from May 31 to October 1. Wet-weather erosion control measures shall be installed and functional by October 1. The time period for land disturbance activities may be extended (either earlier than May 31 or later than October 1) by the City's Engineer after approval by the Stormwater Manager or designee, based on the recommendations of the Soils and Geology Report, with the concurrence from the City's consulting engineer. The modification of dates shall be the minimum necessary, based upon evidence provided by the applicant, to accomplish the necessary project goals.

(3) Revegetation requirements. Where required by this Section, all required revegetation of cut and fill slopes shall be installed prior to the issuance of a certificate of occupancy, acceptance of public facilities, or other time as determined by the Manager.

(4) Inspections and Final Report. Prior to the acceptance of public facilities or issuance of a building permit for a structure, the developer's engineer of record shall provide a final report indicating that the approved grading, drainage, and erosion control measures were installed as per the approved plans, and that all scheduled inspections, as per Section 5.0210(C)(6), were conducted by the engineer of record periodically throughout the project.

5.0225 Trees and Vegetation

Trees and vegetation shall be maintained on site in order to provide protection against soil erosion and earth movement as well as to protect the aesthetic value of those hillside areas that may be highly visible to the surrounding community. Any proposed tree removal shall comply with the provisions of Section 9.1000, including no tree removal on slopes over 15% (before development) that results in clear cutting, as defined in Section 3.0100, except as follows:

(A) The removal of existing trees with a circumference of 25 inches or greater shall be limited to and within 10 feet of those areas required for the grading of roads, driveways, utilities, and the preliminary grading area for building pads. Tree removal that is confined to the approved grading plan (up to the grading limitations of Section 5.0223(A)) shall not constitute "clear cutting" as defined in Section 3.0100.

(B) A Vegetation/Revegetation Plan to stabilize slopes and minimize soil erosion is required based on the findings and recommendations in the Soils and Geology Report. The Vegetation/Revegetation Plan shall be prepared by a licensed Landscape Architect registered in the State of Oregon, and shall discuss any special measures proposed to protect water resources on or near the site for areas identified as particularly highly susceptible to erosion. Temporary erosion control measures, as they relate to construction activity, shall be, at a minimum, consistent with the guidance and requirements presented in the City's Prevention and Sediment Control Manual, and current erosion control and slope stability engineering practices. Revegetated areas shall be continuously maintained until vegetation is established. The maintenance of the revegetation shall be included as part of the Public Facilities Maintenance Bond.

Section 5.0600 Water Quality Resource Area (WQRA) Overlay District

5.0602 Intent

The intent is to protect and improve water quality, to support designated beneficial water uses and to protect the functions and values of existing and newly established Water Quality Resource Areas, which include, but are not limited to:

(A) Provide a vegetated corridor to separate protected water features from development;

(B) Maintain or reduce stream temperatures;

(C) Maintain natural stream corridors;

(D) Minimize erosion, nutrient and pollutant loading into water;

(E) Provide filtration, infiltration and natural water purification;

(F) Stabilize slopes to prevent landslides contributing to sedimentation of water features.

5.0610 Development Standards

(B) To the extent practicable, existing vegetation shall be protected and left in place. Those portions of the Water Quality Resource Area that are not proposed to be impacted by development shall be located and delineated on the site by flags, stakes, fencing or other means. Such markings shall be maintained until construction is completed.

(C) Where existing vegetation has been removed, or the original land contours disturbed, the site shall be revegetated with native vegetation as listed in the Metro Native Plant List. The vegetation shall be established as soon as practicable. Nuisance plants (invasive non-native plants), as identified in the Metro Native Plant List, may be removed at any time. Interim erosion control measures such as mulching shall be used to avoid erosion on bare areas. Nuisance plants shall be replaced with non-nuisance plants by the next growing season.

(E) Additions, alterations, rehabilitation and replacement of existing structures, roadways, driveways, accessory uses and other development that are not exempted by Section 5.0607 (E):

(1) The WQRA provisions shall apply to existing development that is nonconforming, in addition to any other applicable requirements of the Community Development Code.

(2) Additions, alterations, rehabilitation or replacement of existing structures, roadways, driveways, accessory uses and development shall not encroach closer to the Protected Water Feature than the existing location of the structure, roadway, driveway, accessory use or other development.

(3) Additions, alterations, etc. must meet City erosion control standards.

(4) The project shall be conditioned to limit its disturbance and impact on the WQRA to the minimum extent necessary to achieve the proposed addition, alteration, restoration, replacement or rehabilitation.

APPENDIX B
Soil Erosion Potential (RUSLE) and Local Soil Characteristics

Evaluation of Soil Erosion Potential

The erosion potential for critical soil areas can be evaluated using site factors and selected erosion prevention and sediment control BMPs. The most common method of evaluating erosion potential is to estimate annual erosion rates using the Revised Universal Soil Loss Equation (RUSLE), which is a semi-empirical equation based on 10,000 plot-years of data. RUSLE can be used to predict differences in natural erosion potential among various development sites, and to predict differences with and without erosion control BMPs.

REVISED UNIVERSAL SOIL LOSS EQUATION

In Gresham, a construction site shall not exceed the average daily amount of soil loss predicted by the RUSLE.

A = R x K x LS x C x P

Where:

A = Annual rate of erosion in tons per acre per year
R = Rainfall factor
K = Soil erodibility
L = Length of slope
S = Slope steepness
C = Cover factor
P = Conservation practice factor

The Agricultural Research Service (ARS) and Natural Resources Conservation Service (NRCS) are sections of the United States Department of Agriculture (USDA) that have developed a computer application (RUSLE2) to estimate erosion using the RUSLE equation. RUSLE2 uses methods developed over the past century to estimate soil loss, sediment yield, and sediment characteristics from rill and interrill (sheet and rill) erosion caused by rainfall and its associated overland flow. RUSLE2 relies on user input of site specific factors that represent the effects of climatic erosivity, soil erodibility, topography, cover management, and support practices to estimate erosion.

The RUSLE2 computer program, RUSLE databases, a tutorial that describes program mechanics, a slide set that provides an overview of RUSLE2, example calculations, and other supporting information are available for download from any of the following RUSLE2 internet sites:

- University of Tennessee at http://bioengr.ag.utk.edu/RUSLE2/
- USDA-ARS at http://www.sedlab.olemiss.edu/RUSLE/
- USDA- NRCS at ftp://fargo.nserl.purdue.edu/pub/RUSLE2/

Each site factor that influences erosion (i.e., variable in the RUSLE) is described below.

Rainfall/Climate (R)

- Climate, and particularly rainfall intensity and duration are directly related to erosion:
- Droplet size is important from the aspect of splash erosion
- Other considerations include: storm patterns, types of vegetation native to the area, vegetation morphology and growth characteristics, and average annual soil temperatures

Soil Erodibility (K)

Soil erodibility is the propensity for soil particles to become detached by actions of water or wind. The K factor:

- Is a function of soil texture, organic matter content, soil structure and permeability
- Is expressed as numerical values in USDA/NRCS tables

Flow Path Length and Slope (LS)

- The degree to which length and slope (LS Factor) play in erosion can be calculated using USDA/NRCS charts
- Slope Length: distance along flow path to a point where deposition is first likely to occur
- Slope Steepness: ratio of horizontal distance to vertical rise (e.g., 3:1 slope); percentage (e.g., 33 percent slope); or degrees (18 degree slope)

In general:

- The effect of flow path length is not as great as effect of slope steepness
- Long uninterrupted slopes and especially long steep slopes (2:1 horizontal: vertical or greater) should not be constructed
- Long slopes should be shortened by creating contour diversions or benches every 25 feet.
- A convex slope shape increases runoff and magnifies slope erosion
- A concave slope shape enhances infiltration and reduces erosion

Aspect or orientation of slope is important with respect to:

- Vegetation establishment
- Moisture content

Cover

The rate of erosion is related to the amount of permanent or temporary cover. The functions of cover are to:

- Reduce rainfall impact on soil
- Reduce surface water velocities
- Enhance infiltration
- Filter sediment in surface runoff
- Retain soil particles in place and reinforce soil structure
- Promote permanent vegetation establishment

Conservation Practices (P)

Conservation practices are controllable, imaginative, experience-driven, and interactive factors such as slope roughening perpendicular to the direction of runoff. For the most part, they can:

- Enhance the factors of cover and soil texture
- Mitigate the influence of rainfall and runoff
- Modify velocity flow path length and steepness

Soil Survey Information

The USDA/NRCS Multnomah County Area Soil Survey tables contain valuable information to estimate erosion potential using RUSLE, and to assist with design and selection of site BMPs. The Multnomah County Area Soil Survey (USDA/NRCS, OR051), including maps and tables, is accessible on the web at: http://www.or.nrcs.usda.gov/pnw_soil/or_data.html. Additional soil information available online may be found at the same web link.

The county soil survey contains three tables of particular interest: Physical Properties of the Soils; Water Features; and Engineering Index Properties. Relevant information available from each of these tables is discussed below.

Soil Survey Table J1b—Physical Properties of Soils

Erosion factors are shown in Table J1b (presented below for Multnomah County Soils) and include the K factor (labeled as K_f in Table J1b), the K_w factor and the T factor. The erosion factor K_f indicates the erodibility of the fine-earth fraction, or the material less than 0.08 inch in size. Erosion factor K_w indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments. Value listed for K_f factor should be used for factor K in the Revised Universal Soil Loss Equation (RUSLE) as discussed below.

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. K is one of six factors used in RUSLE to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and permeability.

- **The Soil Erodibility Factor K (Kf in Table J1b)** is used in RUSLE and indicates the susceptibility of the fine-earth fraction, or the material less than 0.08 inch in size, of the soil to sheet and rill erosion by rainfall. Rocks and rock fragments in the soil profile are not considered (hence why the factor K_w is not used in the RUSLE equation). Values for K range from 0.02 to 0.69. The higher the value, the more susceptible the soil is to sheet and rill erosion by rainfall.

- **Erosion factor T** is an estimate of the maximum average annual rate of soil erosion by wind or water that can occur without affecting crop productivity over a sustained period. Values of T range from 1 to 5 tons/acre/year and are based on depth of soil to bedrock and the type of bedrock. The T factor is not used for construction site erosion.

- **Wind erodibility groups** are made up of soils that have similar properties affecting their susceptibility to wind erosion in cultivated areas. The soils assigned to group 1 are the most susceptible to wind erosion, and those assigned to group 8 are the least susceptible. The groups are as follows:

Group Number	Soil Description
1	Coarse sands, sands, fine sands, and very fine sands.
2	Loamy coarse sands, loamy sands, loamy fine sands, loamy very fine sands, ash material, and sapric soil material.
3	Coarse sandy loams, sandy loams, fine sandy loams, and very fine sandy loams.
4L	Calcareous loams, silt loams, clay loams, and silty clay loams.
4	Clays, silty clays, noncalcareous clay loams, and silty clay loams that are more than 35 percent clay.
5	Noncalcareous loams and silt loams that are less than 20 percent clay and sandy clay loams, sandy clays, and hemic soil material.
6	Noncalcareous loams and silt loams that are more than 20 percent clay and noncalcareous clay loams that are less than 35 percent clay.
7	Silts, noncalcareous silty clay loams that are less than 35 percent clay, and fibric soil material.
8	Soils that are not subject to wind erosion because of coarse fragments on the surface or because of surface wetness.

- **Wind erodibility index** is a numerical value indicating the susceptibility of soil to wind erosion, or the tons per acre per year that can be expected to be lost to wind erosion and is used in the Wind Erosion Equation (WEQ) and is based on soil texture and the relationship of dry soil aggregates greater than 0.03 inch to potential erosion rates of 0 to 310 tons/acre/year from a wide, bare field. This value applies only to the surface layer. There is a close correlation between wind erosion and the texture of the surface layer, the size and durability of surface clods, rock fragments, organic matter, and a calcareous reaction. Soil moisture and frozen soil layers also influence wind erosion.

Soil Survey Table K1—Water Features

Table K1 (presented below for Multnomah County soils) gives estimates of various water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The four hydrologic soil groups are:

- **Group A**. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

- **Group B**. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

- **Group C**. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

- **Group D**. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas.

The months in the table indicate the portion of the year in which the feature is most likely to be a concern.

- **Wetness** refers to a saturated zone in the soil. Table K1 indicates, by month, depth to the top (upper limit) and base (lower limit) of the saturated zone in most years. Estimates of the upper and lower limits are based mainly on observations of the water table at selected sites and on evidence of a saturated zone, namely grayish colors or mottles (redoximorphic features) in the soil. A saturated zone that lasts for less than a month is not considered a water table.

- **Ponding** is standing water in a closed depression. Unless a drainage system is installed, the water is removed only by percolation, transpiration, or evaporation. Table K1 indicates surface water depth and the duration and frequency of ponding. Duration is expressed as very brief if less than 2 days, brief if 2 to 7 days, long if 7 to 30 days, and very long if more than 30 days. Frequency is expressed as none, rare, occasional, and frequent. None means that ponding is not probable; rare that it is unlikely but possible under unusual weather conditions (the chance of ponding is nearly 0 percent to 5 percent in any year); occasional that it occurs, on the average, once or less in 2 years (the chance of ponding is 5 to 50 percent in any year); and frequent that it occurs, on the average, more than once in 2 years (the chance of ponding is more than 50 percent in any year).

- **Flooding** is the temporary inundation of an area caused by overflowing streams, by runoff from adjacent slopes, or by tides. Water standing for short periods after rainfall or snowmelt is not considered flooding, and water standing in swamps and marshes is considered ponding rather than flooding.

- **Duration and frequency** are estimated. Duration is expressed as extremely brief if 0.1 hour to 4 hours, very brief if 4 hours to 2 days, brief if 2 to 7 days, long if 7 to 30 days, and very long if more than 30 days. Frequency is expressed as none, very rare, rare, occasional, frequent, and very frequent. None means that flooding is not probable; very rare mean that it is very unlikely but possible under extremely unusual weather conditions (the chance of flooding is less than 1 percent in any year); rare that it is unlikely but possible under unusual weather conditions (the chance of flooding is 1 to 5 percent in any year); occasional means that it occurs infrequently under normal weather conditions (the chance of flooding is 5 to 50 percent in any year); frequent means that it is likely to occur often under normal weather conditions (the chance of flooding is more than 50 percent in any year but is less than 50 percent in all months in any year); and very frequent means that it is likely to occur very often under normal weather conditions (the chance of flooding is more than 50 percent in all months of any year).

The information is based on evidence in the soil profile, namely thin strata of gravel, sand, silt, or clay deposited by floodwater; irregular decrease in organic matter content with increasing depth; and little or no horizon development.

Also considered is local information about the extent and levels of flooding and the relation of each soil on the landscape to historic floods. Information on the extent of flooding based on soil data is less specific than that provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

Soil Survey Table H—Engineering Index Properties

Table H (presented below for Multnomah County soils) provides the engineering classifications and the range of index properties for the layers of each soil in the survey area.

- **Depth** to the upper and lower boundaries of each layer is indicated.
- **Texture** is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 0.08 inch in diameter. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is 15 percent or more, an appropriate modifier is added, for example, "gravelly."
- **Classification of the soils** is determined according to the Unified soil classification system (ASTM, 1998) and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO, 1998).

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to particle-size distribution of the fraction less than 3 inches in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as PT. Soils exhibiting engineering properties of two groups can have a dual classification, for example, CL-ML.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of particle-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

If laboratory data are available, the A-1, A-2, and A-7 groups are further classified as A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6. As an additional refinement, the suitability of a soil as subgrade material can be indicated by a group index number. Group index numbers range from 0 for the best subgrade material to 20 or higher for the poorest. The AASHTO classification for soils tested, with group index numbers in parentheses, is given in table R.

- **Rock fragments** larger than 10 inches in diameter and 3 to 10 inches in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage.
- **Percentage (of soil particles) passing designated sieves** is the percentage of the soil fraction less than 3 inches in diameter based on an ovendry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 0.19, 0.08, 0.02, and 0.003 inch, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field.
- **Liquid limit and plasticity index** (Atterberg limits) indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination.

The estimates of particle-size distribution, liquid limit, and plasticity index are generally rounded to the nearest 5 percent. Thus, if the ranges of gradation and Atterberg limits extend a marginal amount (1 or 2 percentage points) across classification boundaries, the classification in the marginal zone is generally omitted in the table.

If you need additional information regarding site-specific soils, contact your state or local NRCS District Conservationist or soil scientist:

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APPENDIX C
Acronyms and Terms

Acronyms

AASHTO	American Association of State Highway and Transportation Officials
AC	acre
ACBs	articulated concrete blocks
AM	arbuscular mycorrhizae
ASTM	American Society for Testing and Materials
BFM	Bonded fiber matrix
BMP	Best Management Practice
CFR	Code of Federal Regulations
CWA	Clean Water Act
DEQ	Department Environmental Quality
EC	erosion control
ECB	erosion control blanket
ECM	ectomycorrhizae
EM	ectomycorrhizae
EP	erosion prevention
EPA	United States Environmental Protection Agency
EPCM	Erosion and Pollution Control Manager
EPSCP	Erosion Prevention and Sediment Control Plan
ESA	Endangered Species Act
H:V	horizontal to vertical
IDF	intensity-duration-rainfall
K	potassium
lbs/acre	pounds per acre
LS	length and slope
N	nitrogen
NCDC	National Climatic Data Center
NOI	Notice of Intent
NOT	Notice of Termination
NPDES	National Pollutant Discharge Elimination System
NPS	non-point sources
NS	non-stormwater pollution control
OAR	Oregon Administrative Rule
P	phosphorus
PAM	poly-acrylamide
PLS	pure live seed

RC	runoff control
RECP	rolled erosion control product
RUSLE	Revised Universal Soil Loss Equation
TDS	total dissolved solids
TMDL	Total Maximum Daily Load
TRM	turf reinforcement mat
UIC	underground injection control
USDA	United States Department of Agriculture
VAM	vesicular-arbuscular mycorrhizae

Terms

Adsorption	The adhesion of a substance to the substance to the surface of a solid or liquid. Heavy metals such as zinc and lead often adsorb onto particles.
Alluvial Soils	Soils developed from transported and relatively recently deposited material (alluvium) characterized by a weak modification (or none) of the original material by soil-forming processes.
Annual Storm	The highest peak storm discharge that is expected in any given year.
Apron	A pad of non-erosive material designed to prevent scour holes developing at the outlet ends of culverts, outlet pipes, grade stablilization structures, and other water-control devices.
Aquifer	An underground, porous, water-bearing, geological formation. The term is generally restricted to materials capable of yielding an appreciable supply of water.
Base Flow	Stream discharge derived from groundwater sources as differentiated from surface runoff. Sometimes considered to include flows from regulated lakes or reservoirs.
Bedrock	The more or less solid rock in place either on or beneath the surface of the earth. It may be soft, medium, or hard and have a smooth or irregular surface.
Berm	A constructed barrier of compacted earth.
Best Management Practices (BMPs)	Physical, structural, and/or managerial practices employed to avoid or mitigate damage or potential damage from the contamination or pollution of surface waters or wetlands. Structural BMPs are actual physical installations; procedural/managerial BMPs, include good housekeeping and employee training.
Catch Basin	A grated inlet, curb opening, or combination inlet, with or without a sump, which admits stormwater to a sewer or subdrain.
Channel	A natural stream or excavated ditch that conveys water.
Channel Stabilization	Protecting the sides and bed of a channel from erosion by controlling flow velocities and flow directions using jetties, drops or other structures and/or by lining the channel with a suitable liner such as vegetation, riprap, concrete or other similar material.
Check Dam	A small dam constructed in a gully or other small watercourse to decrease flow velocity, minimize channel scour and promote sediment deposition.
Clay	(1) Soil fraction consisting of particles less than 0.00008 inch in diameter. (2) A soil texture class, which is dominated by clay or at least has a larger proportion of clay than either silt or sand.
Cohesion	The capacity of a soil to resist shearing stress, exclusive of functional resistance.
Cohesive Soil	A soil that, when unconfined, has considerable strength when air-dried and significant strength when saturated.
Coir	Fiber made from coconut husks.
Compost	Organic residue or a mixture of organic residues and soil that has undergone biological decomposition until it has become relatively stable humus.

Conventional Pollutants	Contaminants (other than nutrients) such as sediment, oil, and vehicle fluids.
Contour	An imaginary line on the surface of the earth connecting points of the same elevation.
Cut	Portion of land surface or area from which earth has been removed or will be removed by excavating the depth below the original ground surface to the excavated surface.
Cut-and-Fill	Process of earth grading by excavating part of a higher area and using the excavated material for fill to raise the surface of an adjacent lower area.
Cutoff Trench	A long, narrow excavation (keyway) constructed along the center line of a dam, dike, levee or embankment and filled with relatively impervious material intended to reduce seepage of water through porous strata.
Design Highwater	The elevation of the water surface at peak flow conditions of the design flood.
Design Storm	Selected storm of a given frequency used for designing a design storm system. Hypothetical storm derived from intensity-duration-frequency curves. A prescribed hyetograph and total precipitation amount (for a specific duration recurrence frequency) used to estimate runoff in order to analyze existing drainage, design new drainage facilities or assess impacts of a proposed project on surface water flow.
Detention	The storage and subsequent release of excess stormwater runoff to control peak discharge rates prior to discharge to the storm sewer or natural drainageway.
Detention Facility	A facility designed to receive and hold stormwater and release it at a slower rate, usually over a number of hours. The full volume of stormwater that enters the facility is eventually released.
Detention Time	The theoretical time required to displace the contents of a tank or unit at a given rate of discharge (volume divided by rate of discharge).
Dewatering	The removal of water temporarily impounded in a holding basin.
Dike	An embankment to confine or control water, often built along the banks of a river to prevent overflow of lowlands; a levee.
Discharge	Usually the rate of water flow; a volume of fluid passing a point per unit time commonly expressed as cubic feet per second, cubic meters per second, gallons per minute, or millions of gallons per day.
Dispersion, Soil	The breaking down of fine soil aggregates into individual particles, resulting in single-grain structure. Ease of dispersion influences the erodibility of soils. Generally speaking, the more easily dispersed the soil, the more erodible it is.
Diversion	A channel with a supporting ridge on the lower side constructed at the top, across, or at the bottom of a slop for the purpose of controlling surface runoff.
Diversion Dike	A barrier built to divert surface runoff.
Drain	A buried slotted or perforated pipe or other conduit (subsurface drain) or a ditch (open drain) for carrying off surplus groundwater or surface water.
Drainage	The removal of excess surface water or groundwater from land by means of ditches or subsurface drains.

Drainage Facilities	Pipes, ditches, detention basins, creeks, culvert bridges, etc., used singularly or in combination with each other for the purpose of conveying or storing stormwater run-off.
Drainageway	A natural or artificial depression that carries surface water to a larger watercourse or outlet such as a river, lake, or bay.
Drop Inlet	Overall structure in which the water drops through a vertical riser connected a discharge conduit or storm sewer.
Earth Dam	Dam constructed of compacted suitable soil materials.
Embankment	A man-made deposit of soil, rock, or other material often used to form an impoundment.
Emergency Spillway	Usually a vegetated earth channel used to safely convey flood discharges around an impoundment structure.
Energy Dissipater	A device used to reduce the energy of flowing water to prevent erosion.
Environment	The sum total of all the external conditions that may act upon a living organism or community to influence its development or existence.
Erodibility	Susceptibility to erosion.
Erosion	The wearing away of the land surface by water, wind, ice, gravity, or other geological agents. The following terms are used to describe different types of water erosion:
Accelerated erosion	Erosion much more rapid than normal or geological erosion, primarily as a result of the activities of man.
Channel erosion	The erosion process whereby the volume and velocity of flow wears away the bed and/or banks of a well-defined channel.
Gully erosion	The erosion process whereby runoff water accumulates in narrow channels and, over relatively short periods, removes the soil to considerable depths, ranging from 1 to 2 feet to as much as 75 to 100 feet.
Rill erosion	An erosion process in which numerous small channels only several inches deep are formed; occurs mainly on recently disturbed and exposed soils.
Splash erosion	The spattering of small soil particles caused by the impact of raindrops on wet soils. The loosened and spattered particles may or may not be subsequently removed by surface runoff.
Sheet erosion	The gradual removal of a fairly uniform layer of soil from the land surface by runoff water.
Erosion Prevention and Sediment Control	Any temporary or permanent measures taken to reduce erosion, control siltation and sedimentation, and ensure that sediment-laden water does not leave a site.
Erosion Prevention and Sediment Control Plan	Plans, specifications, and BMP details intended to prevent and control erosion and sediment related to the project construction activities.
Evapotranspiration	The combined loss of water from an area by evaporation from the soil surface and by transpiration of plants.
Filter Fabric	A woven or non-woven, water permeable material generally made of synthetic products such as polypropylene and used in erosion and sediment control

	applications to trap sediment or prevent the movement of fine soil particles. Often used instead of a filter blanket.
Flood Peak	The highest stage or greatest discharge attained by a flood event. Thus, peak states or peak discharge.
Floodplain	The lowland that borders a stream and is subject to flooding when the stream overflows its banks.
Flood Stage	The stage at which overflow of the natural banks of a stream begins.
Floodway	A channel that is natural, excavated, or bounded by dikes and levees, used to carry flood flows.
Frequency of Storm (Design Storm Frequency)	The anticipated period in years that will elapse before another storm of equal intensity and/or total volume will recur: a 10-year storm can be expected to occur on the average once very 10 years.
Gabion	A wire mesh cage, usually rectangular, filled with rock and used to protect channel banks and other sloping areas from erosion.
Gauge	Device for measuring precipitation, water level, discharge, velocity, pressure, temperature, etc., e.g., a rain gauge. A measure of the thickness of metal, e.g., diameter of wire or wall thickness of steel pipe.
Geotextile	Any permeable textile used with foundation, rock, earth or any other geotechnical engineering-related material as an integral part of a human-made project, structure or system.
Grade	(1) The degree of inclination of a road or slope. (2) The finished surface of canal bed, roadbed, top of embankment, or bottom of excavation; any surface prepared to a design elevation for the support of construction such as paving or the laying of a conduit. (3) To finish the surface of a canal bed, roadbed, top of embankment, or bottom of excavation, or other land area to a smooth, even condition.
Grade Stabilization Structure	A structure for the purpose of stabilizing the grade of a gully or other watercourse, thereby preventing further head-cutting or lowering of the channel bottom.
Gradient	Change of elevation, velocity, pressure, or other characteristics per unit length; slope.
Grading	The cutting and/or filling of the land surface to a desired slope or elevation.
Grass	A member of the botanical family Gramineae, characterized by blade-like leaves that originate as a sheath wrapped around the stem.
Grassed Waterway	A natural or constructed waterway, usually broad and shallow, covered with erosion-resistant grasses and used to safely conduct surface water from an area.
Ground Cover	Low-growing, spreading plans useful for low maintenance landscape areas.
Habitat	The environment in which the life needs of a plan or animal are supplied.
Hazardous Materials	Any material, including any substance, waste, or combination thereof, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may cause, or significantly contribute to, a substantial present or

	potential hazard to human health, safety, property, or the environment when improperly treated, stored, transported, disposed of, or otherwise managed.
Heavy Metals	Metals having a high specific gravity, present in municipal and industrial wastes, that pose long-term environmental hazards. Such metals include cadmium, chromium, cobalt, copper, lead, mercury, nickel and zinc.
Hydrologic Cycle	The circuit of water movement from the atmosphere to the earth and back to the atmosphere through various stages or processes such as precipitation, interception, runoff, infiltration, percolation, storage, evaporation, and transpiration.
Hydrology	The science of the behavior of water in the atmosphere, on the surface of the earth, and underground.
Impervious	A surface, which water, can not easily penetrate. Can include graveled surface as well as paved surfaces.
Infiltration	The percolation of water into the ground.
Inlet	The point at which stormwater from impervious surfaces or conveyance piping enters a stormwater management facility. The term "inlet" can also be used in reference to a catch basin (see definition).
Invert	The inside bottom of a culvert or other conduit.
Land Capability	The suitability of land for use. Land capability classification involves consideration of: (1) the risks of land damage from erosion and other causes, and (2) the difficulties in land use owing to physical land characteristics, including climate.
Land Use Controls	Methods for regulating the uses to which a given land area may be put, including such things as zoning, subdivision regulation, and floodplain regulation.
Loam	A soil textural classification in which the proportions of sand, silt and clay are well balanced. Loams have the best properties for cultivation of plants.
Mean Velocity	The average velocity of a stream flowing in a channel or conduit at a given cross-section or in a given reach. It is equal to the discharge divided by the cross-section area of the reach.
Mitigation	Means, in the following order or importance: 1. Avoiding the impact altogether by not taking a certain action or part of an action. 2. Minimizing impacts by limiting the degree or magnitude of the action and its implementation, by using appropriate technology, or by taking affirmative steps to avoid or reduce impacts. 3. Rectifying the impact by repairing, rehabilitating or restoring the affected environment. 4. Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action and 5. Compensation for the impact by replacing, enhancing, or providing substitute resources or environments.
Mulch	A natural or artificial layer of plant residue or other materials covering the land surface which conserves moisture, holds soil in place, aids in establishing plant

	cover, and minimizes temperature fluctuations.
Natural Grade	The grade of the land in an undisturbed state.
Non-point Source Pollution	Pollution that enters a water body from diffuse origins on the watershed and does not result from discernible, confined, or discrete conveyances.
Non-Stormwater Discharge	Any discharge to the public stormwater system that is not entirely stormwater.
Normal Depth	Depth of flow in an open conduit during uniform flow for the given conditions.
NPDES	National Pollutant Discharge Elimination System. The part of the federal Clean Water Act, which requires permits for point and non-point source discharges.
Nutrients	Essential chemicals for plant and animal growth. Excessive amounts can lead to water quality degradation and algae blooms. Some nutrients are toxic at high concentrations.
Open Drain	Natural watercourse or constructed open channel that conveys drainage water.
Outfall	The point at which collected concentrated stormwater is discharged, generally from a pipe(s), from a project site to an open drainage element such as a ditch, channel, swale, stream, river, pond, lake or wetland.
Outlet	Point of water disposal from a stream, river, lake tidewater, or artificial drain.
Outlet Channel	A waterway constructed or altered primarily to carry water from man made structures, such as smaller channels, tiles, lines, and diversions.
Peak Run-off	The maximum stormwater run-off rate (cfs) determined for the design storm, or design rainfall intensity.
Permeability	A generic term for the ability of a material to conduct a fluid.
Permeable Soils	Soil materials with filtration rate of 10 minutes per inch or better. Such soils allow infiltration and reduce or eliminate surface and stormwater runoff. Classified as SCS (Soil Conservation Services) Type A.
Permeability Rate	The rate at which water will move through a saturated soil. Permeability rates are classified as follows: • Very slow – Less than 0.06 inch per hour • Slow – 0.06 to 0.20 inch per hour • Moderately slow – 0.20 to 0.63 inch per hour • Moderate – 0.63 to 2.0 inches per hour • Rapid – 6.3 to 20.0 inches per hour • Very rapid – More than 20.0 inches per hour
Permittivity	For a geotextile, the volumetric flow rate if water per unit cross-section area, per unit head, under laminar flow conditions, in the normal direction through the fabric.
Point Source	Any discernible, confined and discrete conveyance, including but not limited to, any pipe ditch, channel, tunnel, conduit, well, discrete fissure, container, roller stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged.
Point Source Pollutants	Pollution, which enters a water body resulting from discernible confined or

	discrete conveyances.
Pollutant	Anything which causes or contributes to pollution.
Pervious	Allowing movement of water.
Porosity	The volume of pore space in soil or rock.
Practicable	Available and capable of being done as determined by the Stormwater Division Manager, after taking into consideration cost, existing technology, and logistics in light of overall project purpose, referred to in the Clean Water Act as "Maximum Extent Practicable".
pH	A numerical measure of hydrogen ion activity. The neutral point is pH 7.0. All pH values below 7.0 are acid and all above 7.0 are alkaline.
Rainfall Intensity	The rate at which rain is falling at any given instant, usually expressed in inches per hour.
Rational Method	A means of computing storm drainage flow rates, Q, by use of the formula $Q=CIA$, where C is coefficient describing the physical drainage area, I is the rainfall intensity and A is the area.
Receiving Stream	The body of water into which runoff or effluent is discharged.
Retention	The process of collecting and holding surface and stormwater run off with no surface outflow from a developed property.
Retention Facility	A facility designed to receive and hold stormwater runoff. Rather than storing and releasing the entire runoff volume, retention facilities permanently retain water on-site, where it infiltrates, evaporates, or is absorbed by surrounding vegetation. In this way, retention facilities reduce the total volume of excess water released to downstream conveyance facilities.
Riparian	Pertaining to banks of streams, wetlands, lakes or tide waters.
Riser	The inlet portions of a drop inlet spillway that extends vertically from the pipe conduit barrel to the water surface.
Runoff	That portion of precipitation that flows from drainage area on the land surface, in open channels or in stormwater conveyance systems.
Salmonid	A member of the fish family *Salmonidae*. Includes Chinook, coho, chum, sockeye and pink salmon, cutthroat, steelhead, rainbow, Dolly varden, brook, kokanee and whitefish.
Sand	(1) Soil particles between 0.002 and 0.079 inch in diameter. (2) A soil textural class inclusive of all soils which are at least 70% sand and 15% or less clay.
Saturation	In soils, the point at which a soil or an aquifer will no longer absorb any amount of water without losing an equal amount.
Scour	The clearing and digging action of flowing water, especially the downward erosion caused by stream water in sweeping away mud and silt from the streambed and outside bank of a curved channel.
Sediment	Fragmented material originated from weathering and erosion of rocks and unconsolidated deposits. The material is transported by, suspended in, or

	deposited by water.
Sedimentation	Deposition of erosional debris-soil sediment transported by water from a higher elevation to an area of lower gradient where sediments are deposited as a result of slack water.
Sediment Delivery Ratio	The fraction of the soil eroded from upland sources that actually reaches a stream channel or storage reservoir.
Sediment Discharge	The quality of sediment, measured in dry weight or by volume, transported through a stream cross-section in a given time. Sediment discharge consists of both suspended load and bedload.
Seedbed	The soil prepared by natural or artificial means to promote the germination of seed and the growth of seedlings.
Seedling	A young plant grown from seed.
Sheet Erosion	Relatively uniform removal of soil form an area without the development of conspicuous water channels.
Sheet Flow	Relatively uniform flow over a plan surface without concentration of water into conspicuous channels.
Shoot	The above-ground portion of a plant.
Silt	Fine textured soil particles, including day and sand, as differentiated from coarse particles of sand and gravel.
Siltation	Process by which a river, lake or other water body becomes clogged with sediment. Siltation can clog gravel beds and prevent successful salmon spawning.
Slope	Degree of deviation of a surface from the horizontal; measured as a numerical ration or percent. Expressed as a ratio, the first number is the horizontal distance (run) and the second is the vertical distance (rise), e.g., H:V = 2:1.
Soil	The unconsolidated mineral and organic material on the immediate surface of the earth that serves as a natural medium for the growth of land plants.
Soil Horizon	A horizontal layer of soil that, through processes of soil formation, has developed characteristics distinct from the layers above and below.
Soil Profile	A vertical section of the soil from the surface through all horizons.
Soil Stabilization	Use of rock-lining, vegetation or other methods to prevent soil movement when loads are applied to the soil.
Soil Structure	The relation of particles or groups of particles which impart to the whole soil a characteristic manner of breaking; some types are crumb structure, block structure, platy structure, and columnar structure.
Soil Texture	The physical structure or character of soil determined by the relative proportions of the soil separates (sand, silt and clay) of which it is composed.
Spillway	A passage such as a paved apron or channel for surplus water over or around or through a dam or similar structure. An open or closed channel, or both, sued to convey excess water from a reservoir. It may contain gates, whether manually or automatically controlled, to regulate the discharge of excess water.
Storm Frequency	The statistical time interval between major storms of predetermined intensity and runoff volumes for which storm sewers and other structures are designed and

	constructed to handle hydraulically without surcharge or backflood.
Storm Sewer	A sewer that carries stormwater, surface drainage, street wash and other wash waters, but excludes sewage and industrial wastes. Also called a storm drain.
Stormwater	Surface runoff and drainage associated with rain/storm events and snowmelt.
Stormwater Facility	A constructed component of a stormwater drainage system, designed or constructed to perform particular function, or multiple functions. Stormwater facilities include pipes, swales, ditches, culverts, street gutters, detention basins, retention basins, constructed wetlands and other.
Streambanks	The usual boundaries, not the flood boundaries, of a stream channel. Right and left banks are named facing downstream.
Subsoil	The B-horizons of soils with distinct profiles. In soils with weak profile development, the subsoil can be defined as the soil below which roots do not normally grow.
Subsurface Drain	A pervious backfilled trench usually containing stone and perforated pipe for intercepting groundwater or seepage.
Surface Runoff	Precipitation that falls onto the surfaces of roofs, streets, the ground, etc., and is not absorbed or retained by that surface, but collects and runs off.
Suspended Solids	Organic or inorganic particles suspended in and carried by water, sand, mud, clay as well as solids.
Swale	A broad, bottomed, shallow, vegetation lined channel, which allows for reduced flow velocity and filtration of stormwater, generally with flow depths less than one foot.
Time of Concentration (T of C)	The time it takes stormwater runoff to travel from the most distant point on a particular site or drainage basin to a particular point of interest.
Toe of Slope	The base or bottom of a slope at the point where the ground surface abruptly changes to a significantly flatter grade.
Topography	General term to include characteristics of the ground surface such as plains, hills, mountains, degree of relief, steepness of slopes, and other physiographic features.
Topsoil	The dark-colored surface layer of A horizon of a soil. When present it ranges in depth from a fraction of an inch to 2 or 3 feet; equivalent to the plow layer of cultivated soils. Commonly used to refer to the surface soil layer(s), enriched in organic matter and having textural and structural characteristics favorable for plant growth.
Total Suspended Solids (TSS)	Matter suspended in stormwater excluding litter, debris, and other gross solids exceeding 1 millimeter in diameter.
Toxicity	The characteristics of being poisonous or harmful to plant animal life; the relative degree or severity of the characteristic.
Trash Rack	A structural device used to prevent debris from entering a pipe spillway or other hydraulic structure.
Turbidity	Is caused by silt and clay particles, particles smaller than 0.0008 inch, suspended in water. Measurement of turbidity can be done by turbidimeter which measures light-beam scatter caused by small suspended particles and converts it to NTU

	(nephelometric turbidity unit).
Turf	Surface soil supporting a dense growth of grass and associated root mat.
Vegetative Stabilization	Protection of erodible or sediment-producing areas with: • Permanent seeding, producing long-term vegetative cover, • Short-term seeding, producing temporary vegetative cover, or • Sodding, producing areas covered with a turf of perennial sod-forming grass.
Watercourse	A channel in which a flow of water occurs, either continuously or intermittently, with some degree of regularity. Watercourses may be either natural or artificial.
Water Quality	A term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.
Water Resources	The supply of groundwater and surface water in a given area.
Watershed Area	All land and water within the confines of a drainage divide.
Water Table	The free surface of the groundwater. That surface subject to atmospheric pressure under the ground, generally rising and falling with the season, or from other conditions such as water withdrawal.
Weir	Device for measure or regulating the flow of water.
Wet Pond	A facility treating stormwater by utilizing a permanent pool of water to remove conventional pollutants from runoff. Treatment mechanisms include sedimentation, biological uptake and plant filtration.
Wet Weather Season	Defined for the purposes of construction and development in the City of Gresham as the period between October 1st and the following June 1st.
Wetlands	Those lands adjacent to watercourses or isolated therefrom which may normally or periodically be inundated by the waters from the watercourse or the drainage waters from the drainage basin which it is located. These include swamps, bogs, sinks, marshes, and lakes, all of which are considered to be part of the watercourse and drainage system of the City and shall include the headwater areas where the watercourse first surfaces. They may be, but are not necessarily, characterized by special soils such as peat, muck, and mud.

APPENDIX D

Conversion and Reference Tables

Metric Conversion Tables

Measurement in:	From English Units:	To Metric Units:	Multiply By
Length	inch (in)	millimeter (mm)	25.40
	foot (ft)	meter (mm)	0.3048
	yard (yd)	meter (mm)	0.9144
	mile (mi)	kilometer (km)	1.609
Area	in^2	mm^2	645.2
	ft^2	m^2	0.0929
	yd^2	m^2	0.8361
	mi^2	km^2	2.590
	acre	hectare (ha)	0.4047
	acre	m^2	4047

Quantity	From SI Units	To English Units	Divide By
Length	km	mile	1.609
	m	yard	0.9144*
	m	foot	0.3048*
	mm	inch	25.4*
Area	km^2	square mile	2.59
	m^2	acre	4047
	hectare	acre	0.404
	m^2	square yard	0.836
	m^2	square foot	0.092
	mm^2	square inch	645.2

Abbreviations

L	liter
ha	hectares
kg	Kilogram=1x103 grams
m	meter
km	kilometer=1x103 meters
mm	millimeter

Slope Conversion Table

Run:Rise	% Grade	Angle Degree
100:1	1.0	0.6
90:1	1.1	0.6
80:1	1.3	0.7
70:1	1.4	0.8
60:1	1.7	1.0
50:1	2.0	1.1
40:1	2.5	1.4
35:1	2.9	1.6
30:1	3.3	1.9
25:1	4.0	2.3
20:1	5.0	2.9
19:1	5.3	3.0
18:1	5.6	3.2
17:1	5.9	3.4
16:1	6.3	3.6
15:1	6.7	3.8
14:1	7.1	4.1
13:1	7.7	4.4
12:1	8.3	4.8
11:1	9.1	5.2
10:1	10.0	5.7
9:1	11.1	6.3
8:1	12.5	7.1
7:1	14.3	8.1
6:1	16.7	9.5
5:1	20.O	11.3
4:1	25.0	14.0
3:1	33.3	18.4
2:1	50.0	26.6
1:1	100.0	45.0
How to calculate percent slope:	Rise or (v) vertical change elevation (feet) * 100 Run or (h) horizontal distance (feet)	
Divide rise by run, and multiply by 100, e.g.,	_15 vertical feet_ * 100 = 0.30 * 100 = 30% 45 horizontal feet	

Seed or Fertilizer Hydraulic Application

Application Load (W_{sf})	Area of Coverage (A)													
	Application Rates of Pure Live Seed (R_{sf})													
	20 lb/acre		40 lb/acre		60 lb/acre		80 lb/acre		100 lb/acre		200 lb/acre		400 lb/acre	
Pounds	acre	ft^2	acre	ft^2	acre	ft^2	acre	ft^2	acre	ft^2	acre	ft^2	acre	ft^2
10	0.50	21,780	0.25	10,890	0.17	7,260	0.13	5,445	0.10	4,356	0.05	2,178	0.03	1,089
20	1.00	43,560	0.50	21,780	0.33	14,520	0.25	10,890	0.20	8,712	0.10	4,356	0.05	2,178
30	1.50	65,340	0.75	32,670	0.50	21,780	0.38	16,335	0.30	13,068	0.15	6,534	0.08	3,267
40	2.00	87,120	1.00	43,560	0.67	29,040	0.50	21,780	0.40	17,424	0.20	8,712	0.10	4,356
50	2.50	108,900	1.25	54,450	0.83	36,300	0.63	27,225	0.50	21,780	0.25	10,890	0.13	5,445
60	3.00	130,680	1.50	65,340	1.00	43,560	0.75	32,670	0.60	26,136	0.30	13,068	0.15	6,534
70	3.50	152,460	1.75	76,230	1.17	50,820	0.88	38,115	0.70	30,492	0.35	15,246	0.18	7,623
80	4.00	174,240	2.00	87,120	1.33	58,080	1.00	43,560	0.80	34,848	0.40	17,424	0.20	8,712
90	4.50	196,020	2.25	98,010	1.50	65,340	1.13	49,005	0.90	39,204	0.45	19,602	0.23	9,801
100	5.00	217,800	2.50	108,900	1.67	72,600	1.25	54,450	1.00	43,560	0.50	21,780	0.25	10,890
120	6.00	261,360	3.00	130,680	2.00	87,120	1.50	65,340	1.20	52,272	0.60	26,136	0.30	13,068
140	7.00	304,920	3.50	152,460	2.33	101,640	1.75	76,230	1.40	609,984	0.70	30,492	0.35	15,246
160	8.00	348,480	4.00	174,240	2.67	116,160	2.00	87,120	1.60	69,696	0.80	34,848	0.40	17,424
180	9.00	392,040	4.50	196,020	3.00	130,680	2.25	98,010	1.80	78,408	0.90	39,204	0.45	19,602
200	10.00	435,600	5.00	217,800	3.33	145,200	2.50	108,900	2.00	87,120	1.00	43,560	0.50	21,780
220	11.00	479,160	5.50	239,580	3.67	159,720	2.75	119,790	2.20	95,832	1.10	47,916	0.55	23,958
240	12.00	522,720	6.00	261,360	4.00	174,240	3.00	130,680	2.40	104,544	1.20	52,272	0.60	26,136
260	13.00	566,280	6.50	283,140	4.33	188,760	3.25	141,570	2.60	113,256	1.30	56,628	0.65	28,314
280	14.00	609,840	7.00	304,920	4.67	203,280	3.50	152,460	2.80	121,968	1.40	60,984	0.70	30,492
300	15.00	653,400	7.50	326,700	5.00	217,800	3.75	163,350	3.00	130,680	1.50	65,360	0.75	32,670

“Application Load” is in Pure Live Seed.

Gross weight of seed can be converted by the Pure Live Seed (PLS) Rate [%Purity x %Germination = %PLS; W_{sf} = Gross Weight x %PLS]

Wood Fiber Mulch Hydraulic Application

2,000 lb/acre Application Rate (R_{wf})				
Wood Fiber	Water Required for Application		Area of Coverage (A)	
(W_{wf})	Average (V_{wa})	Maximum (V_{wm})		
	40 lbs mulch / 100 gal water	50 lbs mulch / 100 gal water		
Pounds	Gallons[1]	Gallons[1]	ft^2	Acres
500	1,250	1,000	10,890	0.25
600	1,500	1,200	13,068	0.30
700	1,750	1,400	15,246	0.35
800	2,000	1,600	17,424	0.40
900	2,250	1,800	19,602	0.45
1,000	2,500	2,000	21,780	0.50
1,100	2,750	2,200	23,958	0.55
1,200	3,000	2,400	26,136	0.60
1,300	---	2,600	28,314	0.65
1,400	---	2,800	30,492	0.70
1,500	---	3,000	32,670	0.75

2,500 lb/acre Application Rate (R_{wf})				
Wood Fiber	Water Required for Application		Area of Coverage (A)	
(W_{wf})	Average (V_{wa})	Maximum (V_{wm})		
	40 lbs mulch / 100gal water	50lbs mulch / 100gal water		
Pounds	Gallons[1]	Gallons[1]	ft^2	Acres
500	1,250	1,000	8,712	0.20
600	1,500	1,200	10,454	0.24
700	1,750	1,400	12,197	0.28
800	2,000	1,600	13,939	0.32
900	2,250	1,800	15,682	0.36
1,000	2,500	2,000	17,424	0.40
1,100	2,750	2,200	19,166	0.44
1,200	3,000	2,400	20,909	0.48
1,300	---	2,600	22,651	0.52
1,400	---	2,800	24,394	0.56
1,500	---	3,000	26,136	0.60

[1] Largest typical hydroseeding equipment has a 3,000 gallon working volume.

Hydraulic Applications

Seed or Fertilizer Hydraulic Application

Area of Coverage

$A\ (\text{acre}) = (W_{sf} / R_{sf})$

$A\ (\text{ft}^2) = (W_{sf} / R_{sf}) * (43{,}560\ \text{ft}^2/\text{acre})$

Seed or Fertilizer Application Rates (lb/acre)	R_{sf}
Weight or Mass of Seed or Fertilizer (lbs)	W_{sf}
Area of Coverage (ft²) & (acres)	A

Wood Fiber Mulch Hydraulic Application

Average Water Required for Application

$V_{wa}\ (\text{gal}) = (W_{wf}) / (40\ \text{lbs mulch} / 100\ \text{gal water})$

Maximum Water Required for Application

$V_{wm}\ (\text{gal}) = (W_{wf}) / (50\ \text{lbs mulch} / 100\ \text{gal water})$

Area of Coverage

$A\ (\text{acre}) = (W_{wf} / R_{wf})$

$A\ (\text{ft}^2) = (W_{wf} / R_{wf}) * (43{,}560\ \text{ft}^2/\text{acre})$

Where:

Wood fiber application rate (lb/acre)	R_{wf}
Weight or mass of wood fiber (lbs)	W_{wf}
Average water requirement (gal)	V_{wa}
Maximum water requirement (gal)	V_{wm}
Area of coverage (ft²) & (acres)	A

Appendix E

Costs & Suppliers

This table provides estimated cost ranges for selected erosion prevention and sediment control BMPs, and their relative effectiveness for convenience of the user. The costs sited are estimates based on typical costs at the time of this writing and are not meant to be exact.

Installed Costs & Effectiveness of Erosion/Sediment Control BMPS

Erosion Prevention and Sediment Control BMP	Unit Cost Installed	Estimated Effectiveness (%)[1]
Sediment Control		
Sediment Fence	$1.50 – 2.00 per lineal foot	95
Compost Berm (12-16 inch height)	$1.75 – 2.00 per lineal foot	95 – 99
Fiber Rolls (9 inch) (12 inch) (9 inch with trackwalking)	$1.50 – 2.00 per lineal foot $2.00 – 2.50 per lineal foot $3.00 – 4.00 per lineal foot	58 95 – 99 84
Erosion Prevention Controls		
Fertilizer	$450 – 550 per acre	N/A
Seeding	$870 – 2,170 per acre	50
Stolonizing	$2,200 per acre + cost of stolons	90
Hydraulic Mulching	$900 – 1,200 per acre	50 – 60
Compost Application (2,000 lbs/acre) (2 inch blanket application) (3-4 inch blanket application)	$900 – 1,200 per acre $7,000 – 10,000 per acre $10,000 – 15,000 per acre	40 – 50 95 – 99 95 – 99
Straw Mulching	$1,800 – 2,100 per acre	90 – 95
Soil Binders		
Plant Material-Based (Short-Term)	$700 – 900 per acre	85 – 99
Plant Material-Based (Long-Term)	$1,200 – 1,500 per acre	60 – 65
Polymeric Emulsion Blends (Including PAM)	$700 – 1,500 per acre	30 – 95
Petroleum Resin-Based	$1,200 – 1,500 per acre	25 – 40
Cementitious Binder-Based	$800 – 1,200 per acre	80 – 85
Hydraulic Matrices (Wood mulch + Soil binder)	$1,000 – 2,000 per acre	65 – 99
Bonded Fiber Matrices	$5,000 – 6,500 per acre	90 – 99
Rolled Erosion Control Products		
Biodegradable		
Jute	$6,000 – 7,000 per acre	65 – 70
Curled Wood Fiber	$8,000 – 10,500 per acre	90 – 99
Straw	$8,000 – 10,500 per acre	90 – 99
Wood Fiber	$8,000 – 10,500 per acre	90 – 99
Coconut Fiber	$13,000 – 14,000 per acre	90 – 99
Coconut Fiber Net	$30,000 – 33,000 per acre	90 – 99
Straw Coconut	$10,000 – 12,000 per acre	90 – 99
Non-Biodegradable		
Plastic Netting	$2,000 – 2,200 per acre	< 50
Plastic Mesh	$3,000 – 3,500 per acre	75 – 80
Synthetic Fiber w/Netting	$34,000 – 40,000 per acre	90 – 99
Bonded Synthetic Fibers	$45,000 – 55,000 per acre	90 – 99
Combination Synthetic and Biodegradable Fibers	$30,000 – 36,000 per acre	85 – 99

Source: Erosion Control Pilot Study Report, Caltrans, June 2000, Table 4-1; Updated May 2004

[1] Effectiveness is based on the percentage of sediment retained by weight in laboratory tests. A high effectiveness rating may not equate to meeting water quality standards because some controls such as sediment fence retain larger particles and allow fines to pass which remain in suspension.

The following vendor lists are for public information and convenience of the user. Mention of company names is not an endorsement by the City of Gresham.

Material Suppliers

ACF West, Inc.
8951 SE 76 Drive
Portland, OR 97206
(503) 771-5115
(800) 878-5115

C.S.I.
3500 SE Columbia
Bldg 44-100
Vancouver, WA 98661
(800) 426-7976

Layfield Plastics
3890 Hammer Drive
Bellingham, WA 98226
(800) 796-6868

Oregon Culvert Company
10780 SW Tualatin-Sherwood Rd
Tualatin, OR 97062
(503) 692-0401

Northwest Linings & Geotextile Products, Inc.
21000 77th Ave, South
Kent, WA 98032
(206) 872-0244

Contech Construction Products
710 SW Armco Ave
Hillsboro, OR 97123
(503)648-4123

Lakeside Reclamation
14930 SW VanDermost Road
Beaverton, OR 97007
(503) 628-1866

Emerald Seed & Supply
9330 NE Halsey St
Portland, OR 97220
(503) 254-8414

Rexius Forest By-Products, Inc.
17550 SW 63rd
Lake Oswego, OR 97035
(503) 635-5865

Bark Blowers, Inc.
PO Box 512
Beaverton, OR 97075
(503) 248-2275

Best Mix Concrete Supply
3150 SE TV Hwy
Hillsboro, OR 97123
(503) 648-3100

Coconut Palm Resources, Inc.
2459 SE TV Hwy
Hillsboro, OR 97123
(503) 649-8101

Native Plant and Seed Suppliers

Bosk Dell Natives
23311 SW Bosky Dell
West Linn, OR 97068
(503) 638-5945

Hobbs & Hopkins, Ltd.
1712 SE Ankeny
Portland, OR 97214
(503) 239-7518

Granite Seed
1697 W 211 North
Lehi, UT 84043
(801) 768-4422

Hughes Water Gardens
25289 SW Stafford Road
Tualatin, OR 97062
(503) 638-1709

Quail Ridge Nursery
33689 S Ball Road
Molalla, OR 97038
(503) 829-3106

Samuel J Rich Nursery
9803 Yergen Road
Aurora, OR 97002
(503)678-2828

Serendipity Nursery
8400 S Sconce Road
Canby, OR 97013
(503) 651-2122

Willowell Nursery
8160 SW Landau St
Tigard, OR 97223
(503) 768-5976

Emerald Seed & Supply
9330 NE Halsey St
Portland, OR 97220
(503) 254-8414
[Seed only]

Erosion Prevention and Sediment Control Installers

Krueger's Associated Landscape
& Supply, Inc.
PO Box 32
North Plains, OR 98037
(503) 647-1000

Kwik-Way Erosion Control
18860 S Pear Road
Oregon City, OR 97045
(503) 631-3204

Metropolitan Landscape, Inc.
PO Box 000
Beaverton, OR 97075
(503) 642-5684

Anderson's Erosion Control
PO Box 205
Junction City, OR 97448
(503) 998-2062

Northwest Hydro-Mulchers, Inc.
37621 SE Bearcreek Ln
Boring, OR 97015
(503) 668-5531

Erosion Control Services, Inc.
29895 SW Kinsman Road
Wilsonville, OR 97070
(503) 682-3211

Verchan Environmental Const.
14314 SW Allen Blvd # 122
Beaverton, OR 97005
(503) 626-1122

Erosion Control Northwest, Inc.
22821 Boones Ferry Rd, NE.
Aurora, OR 97002
(503) 678-7990

Dave Jossi & Sons
10490 NW Gravelland Road
Hillsboro, OR 97124
(503) 647-5641

W.E. Dotzenrod Construction
PO Box 5395
Aloha, OR 97006
(503) 222-0561

Ben Fox, Inc.
7028 SE Renada St
Milwaukie, OR 97267
(503) 654-8816

Erosion Control Contractors of Oregon
2077 Kindle Way
Stayton, OR 97383
(503) 580-7417

Dean Petshow Construction
471 Willomina Ave
Forest Grove, OR 97116
(503) 359-9453
(503) 267-8114

Street Sweeping

Mid-State
PO Box 926
Sherwood, OR 97140
(503) 625-0596

All Vac (catch basins)
10121 N Oregonian Ave
Portland, OR 97203
(503) 289-4063

Portland Sweeping Service
(503) 222-2262

Coast Services
PO Box 23697
Tigard, OR 97281
(503) 227-4515

Tracy's Sweeping
(503) 631-7911

Western Pacific
PO Box 4618
Vancouver, WA 98662
(503) 646-0103

Pavement Maintenance, Inc.
(503) 655-1170

Green Waste Disposal & Compost Suppliers

Yard debris compost is produced commercially by several local processors. It is made from yard wastes such as grass clippings, leaves, and branches. It can be used as top dressing, mulch, soil amendment, and erosion control.

The following list is provided for convenience only. Processors may sell their compost in bulk at their locations; some deliver it to Gresham locations. The listing of companies below are not endorsements by the City of Gresham.

Metro Regional Services regulates green waste processing facilities in this area. Additional information can be found at www.metroregion.org or by calling 503-234-3000.

All Wood Recyclers
223rd and Marine Dr
Fairview, OR 97024
(503) 667-5497

American Compost & Recycling
9707 N Columbia Blvd
Portland, OR
(503) 286-0886

Circle S Landscaping
22420 NE Halsey
Fairview, OR
503-667-6820

East County Recycling
12409 NE San Rafael
Portland, OR
503-253-0867

Grimm's Fuel Company
18850 SW Cipole Rd
Tualatin, OR 97062
503-636-3623

McFarlane's Bark
13345 SE Johnson Rd.
Milwaukie, OR 97222
(503) 659-4240

Northwest Wood & Fiber
11005 NE Marx Street
Portland, OR
503-252-2614

S & H Logging
20200 SW Stafford Rd
Tualatin, OR 97062
(503) 638-1011

Wood Waste Management
7315 NE 47th Ave
Portland, OR
503-493-3370

APPENDIX F

Sources of Information and References

Sources of Information for Preparing Erosion Prevention and Sediment Control Plans

Organization	URL
City of Gresham Stormwater Division	www.ci.gresham.or.us/departments/des/stormwater/
Oregon Seed Certification Service	www.oscs.orst.edu
Natural Resource Conservation Service	www.or.nrcs.usda.gov
International Erosion Control Association (IECA)	www.ieca.org
IECA Pacific Northwest Chapter	www.pnwieca.org
West Coast Weather Observations	www.ocs.orst.noaa.gov
Oregon Coast and Pacific NW Weather	IWIN.nws.noaa.gov/iwin/or/or.html
Oregon Department of State Lands	statelands.dsl.state.or.us
Oregon Department of Fish and Wildlife	www.dfw.state.or.us
Oregon Department of Environmental Quality	http://www.deq.state.or.us/wq/
Oregon Department of Agriculture	www.oda.state.or.us/oda.html
US Geological Survey	www.usgs.gov
US Army Corps of Engineers-Portland District	www.nwp.usace.army.mil/op/g/home.asp
NOAA National Weather Service	www.wrh.noaa.gov

References

Abramson, L.W.; Lee, T.S.; Sharma, S.; and Boyce, G.M. 1996. Slope Stability and Stabilization Methods. John Wiley and Sons, New York, NY.

Abramson, L.W.; Thomas, S.L.; Sharma, S.; and Boyce, G.M. 2002. Slope Stability and Stabilization Measures, 2nd Edition. John Wiley and Sons, New York, NY.

Alexander, R. 2002. National Specifications for Highway Use of Compost. BioCycle 43(4):74-77. April 2002.

Alexander, R. 2003. Standard Specifications for Compost for Erosion/Sediment Control. R. Alexander & Associates, Apex, NC.

Allen, H.H. and Fischenich, J.C. 2001. Brush Mattresses for Streambank Erosion Control. U.S. Army Engineer Research and Development Center, Vicksburg, MS. ERDC TN EMRRP- SR-23.

Allen, H.H. and Fischenich, J.C. 1999. Coir Geotextile roll and wetland plants for streambank erosion control. U.S. Army Engineer Research Development Center, Vicksburg, MS. ERDC TN-EMRRP-SR-04. www.wes.army.mil/el/emrrp

American Association of State Highway and Transportation Officials (AASHTO). 2003. Standard Specifications for Compost for Erosion/Sediment Control (Compost Blankets MP-10). AASHTO, Washington, DC.

Austin, D.N. and Theisen, M.S. 1994. BMW Extends Vegetation Performance Limits. IFAI Geotechnical Fabrics Report 12(4):8-16. April/May 1994.

Biedenharn, D.S.; Elliott, C.M.; and Watson, C.C. 1997. The WES Stream Investigation and Streambank Stabilization Handbook. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS. pp. 225-227.

Bonaparte, R.; Holtz, R.D.; and Giroud, J.P. 1987. Soil reinforcement design using geotextiles and geogrids. Geotextile Testing and the Design Engineer, ASTM STP 952. American Society for Testing and Materials, Philadelphia, PA. pp. 69-116. [J.E. Fluet, Jr., (ed.)].

Briggs, J.A. and Munda, B. 1992. Collection, Evaluation and Production of Cottonwood Poles for Riparian Area Improvement. Final Report to the USDA FWS, USDA.-SCS, Tucson Plant Materials Center, Tucson, AZ.

Brown, K. 2000. Urban Stream Practices: An Initial Assessment. Center for Watershed Protection, Ellicott City, MD.

Buffington, J.M. and Montgomery, D.R. 1997. A systematic analysis of eight decades of incipient motion studies, with special reference to gravel-bedded rivers. Water Resources Research 33(8):1993-2029.

California Stormwater Quality Association (CASQA). 2003. California Stormwater BMP Handbook—Construction. CASQA, Menlo Park, CA. www.cabmphandbooks.com.

Caltrans. 2000. Erosion Control Pilot Study Report, June 2000. California Department of Transportation, Sacramento, CA.

Caltrans. 2001. Caltrans Erosion Control Training for Landscape Architects, Section 8—Seed and Fertilizer. California Department of Transportation, Sacramento, CA.

Caltrans. 2002. Caltrans Temporary Erosion Control Training for Designers Manual. California Department of Transportation, Sacramento, CA.

Caltrans. 2003. Storm Water Quality Handbooks, Construction Site Best Management Practices Manual. California Department of Transportation, Sacramento, CA.

Cedergren, H.R. 1989. Seepage, Drainage, and Flow Nets. 3rd edition. John Wiley and Sons, New York, NY.

Cheng, F. 2003. GeoCells: A first for Alberta transportation. Technical Standards Branch Newsletter 2(2). June 2003.

Connecticut Department of Environmental Protection. 2001. Using Compost to control Soil Erosion, Establish and Amend Planting Backfill, A Research Summary. Connecticut Department of Environmental Protection, Hartford, CT.

Coppin, N.J. and Richards, I. 1990. Use of Vegetation in Civil Engineering. Butterworths, Sevenoaks, Kent, England.

Crowe, R.E.; Sent, D.F.; and Martin, S. 1995. The Protection and Rehabilitation of Dams Using Cellular Confinement Systems. Presto Products Company, Appleton, WI. www.prestogeo.com

DePasquale, A.J. and Leatherman, D. 2000. Geocell Wall and Channel Protection for U.S. Army Corps Flood Control Project. In: Proceedings of Conference 31, International Erosion Control Association, Steamboat Springs, CO.

DePasquale, A.J.; Leatherman, D.; and Thomas, R. 2001. Molly Ann's Brook Channel Protection System. Geotechnical Fabrics Report January/February 2001.

DI Goldman, S.J.; Jackson, K.; and Bursztynsky, T.A. 1986. Erosion and Sediment Control Handbook. McGraw Hill, New York, NY. pp. 7.237.27 and 8.618.66.

Diversified Landscape Company. (unk.) Erosion Control Technical Data. Diversified Landscape Company, Winchester, CA.

Edminster, F.C.; Atkinson, W.S.; and McIntyre, A.C. 1949. Streambank Erosion Control on the Winooski River, Vermont. USDA Soil Conservation Service, Washington, DC. Report No. 837

EPRI. 2002. Best Management Practices (BMPs) Manual for Access Road Crossings of Wetlands and Waterbodies. Electric Power Research Institute, Palo Alto, CA.

Erosion Control Technology Council (ECTC). 1997. Erosion Control Technology Council Guidance Manual. Erosion Control Technology Council, St. Paul, MN.

Erosion Control Technology Council (ECTC). 2001. Recommendations on Proposed FHWA FP03 Specification. Erosion Control Technology Council, St. Paul, MN.

Escarameia, M. 1998. River and Channel Revetments. Thomas Telford, Ltd., London, England.

Faucette, B. and Risse, M. 2002. Controlling erosion with compost and mulch. BioCycle 43(6):26-28. June 2002.

Fenchel, G.; Oaks, W.; and Swenson, E. 1988. Selecting Desirable Woody Vegetation for Environmental Mitigation and Controlling Wind Erosion and Undesirable Plants in the Rio Grande and Pecos River Valleys of New Mexico. Five year interim report (1988-87): USDA-SCS, Los Lunas Plant Materials Center, Los Lunas, NM.

Filtrexx. Filtrexx Compost Information. Filtrexx, Grafton, OH.

Fischenich, C. 2000. Irrigation systems for establishing riparian vegetation. U.S. Army Engineer Research and Development Center, Vicksburg, MS. ERDC TN-EMRRP-SR-12. www.wes.army.mil/el/emrrp

Fischenich, C. 2001. Stability thresholds for stream restoration materials. U.S. Army Engineer Research and Development Center, Vicksburg, MS. ERDC-TN-EMRRP-SR-29. www.wes.army.mil/el/emrrp

Fischenich, C. 2001. Stability Thresholds for Stream Restoration Materials. U.S. Army Engineer Research and Development Center, Vicksburg, MS. ERDC TN EMRRP- SR-29. www.wes.army.mil/el/emrrp

Fischenich, J.C. 2001. Impacts of stabilization measures. U.S. Army Engineer Research and Development Center, Vicksburg, MS. ERDC TN-EMRRP-SR-32.

FISRWG. 1998. Stream Corridor Restoration: Principles, Processes, and Practices. Federal Interagency Stream Restoration Working Group [Fifteen Federal agencies of the U.S. Government].

Florineth, F. 1982. Experiences with bioengineered measures for watercourses in mountains. Landschaftswasserbau, TU Wien 3:243-262.

Fortier, S. and Scobey, F.C. 1926. Permissible canal velocities. Trans. ASCE, 89, Paper No. 1588 (1926):940-984.

Freeman, G.E. and Fischenich, J.C. 2000. Gabions for Streambank Erosion Control. U.S. Army Engineer Research and Development Center, Vicksburg, MS. ERDC TN-EMRRP-SR-22.

Fripp, J. 2002. Compilation of Allowable Shear and Velocity Data. USDA Natural Resources Conservation Service, Fort Worth, TX.

Gas Research Institute (GRI). 2002. Final report, erosion and sediment control manual (Best management practices for natural gas pipeline construction projects). Gas Research Institute, Des Plaines, IL. GRI-02/0107.

Gerstgraser, C. 1999. The effect and resistance of soil bioengineering methods for streambank protection. In: Proceedings of Conference 30. International Erosion Control Association, Steamboat Springs, CO.

Glanville, T.D.; Richard, T.L.; and Persyn, R.A. 2003. Final Report: Impacts of Compost Blankets on Erosion Control, Revegetation, and Water Quality at Highway Construction Sites in Iowa. Iowa State University, Ames, IA.

Gray, D.H. 1989. Engineering and Physical Properties of Coir Geotextiles. Report prepared for Belton Corp., June 1989.

Gray, D.H. 1991. Preface. In: Proceedings of Workshop on Biotechnical Stabilization, 21-23 August 1991. University of Michigan, Ann Arbor, MI.

Gray, D.H. and Leiser, A. 1982. Biotechnical Slope Protection and Erosion Control. Van Nostrand Reinhold, New York, NY.

Gray, D.H. and Leiser, A. 1992. Biotechnical Slope Protection and Erosion Control. VanNostrand Reinhold, New York, NY.

Gray, D.H. and Sotir, R.B. 1996. Biotechnical and Soil Bioengineering Slope Stabilization—A Practical Guide for Erosion Control. John Wiley and Sons, Inc., New York, NY. pp. 286-289.

Harman, W. and Smith, R. 2000. Using root wads and rock vanes for streambank stabilization. NC A&T State University, North Carolina Cooperative Extension Service, Raleigh, NC. River Course Fact Sheet Number 4.

Heede, B.H. 1976. Gully control and development. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Ft. Collins, CO. Research Paper RM-169.

Henderson, J.E. and Shields, F.D., Jr. 1984. Environmental features for streambank protection projects. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS. Technical Report E 84-11. pp. 24-28.

Hoag, J.C. 1993. How to plant willows and cottonwoods for riparian rehabilitation. USDA Natural Resources Conservation Service, Boise, ID. Idaho Plant Materials Technical Note #23.

Hoag, J.C.; Young, G.L.; and Gibbs, J.L. 1991. Advanced Regional Adaptation Trials of Accessions from the Aberdeen Plant Materials Center. Paper presented at the 45th Annual Meeting of the Society for Range Management, Spokane, WA.

Hoag, J.C.; Simonson, B.; Cornforth, B.; and St. John, L. 2001. Waterjet stinger—A tool to plant dormant unrooted cuttings of willows, cottonwoods, dogwoods, and other species. USDA-NRCS, Boise, ID. ID- TN39. Feb. 2001.

Hoitsma, T. 1999. Banking on bioengineering. Civil Engineering 69(1):60-62.

Honnigford, L. 2003. Stabilize Soil and Increase Profits - Guidelines for Installing Rolled Erosion Control Products. Synthetic Industries (SI) 2003. Landlock Turf Reinforcement Mats Innovative Technology Inventory Entry. Erosion Control Technology Council, St. Paul, MN. http://www.epa.gov/region1/assistance/ceit_iti/tech_cos/syntheti.html

Hopkins, T.C., and others. 1988. Slope maintenance and slide restoration. U.S. DOT, Federal Highway Administration, Washington, DC. Rep. No. FHWA-RT-88-040.

Huang, R. 1983. Stability of Earth Slopes. Van Nostrand Reinhold, New York, NY.

Hutchinson, J.N. 1978. Assessment of the effectiveness of corrective measures in relation to geologic conditions and types of slope movement. Bulletin Intl. Association of Engineering Geologists16:131-155.

Johnson, A.W. and Stypula, J.M. (eds.). 1993. Guidelines for Bank Stabilization Projects in the Riverine Environments of King County. King County Department of Public Works, Surface Water Management Division, Seattle, WA.

Johnson, P.A.; Hey, R.D.; Tessier, M.; and Rosgen, D.L. 2001. Use of vanes for control of scour at vertical wall abutments. Journal of Hydraulic Engineering 127(3):772-778.

Knight, S.S. and Cooper, C.M. 1991. Effects of bank protection on stream fishes. pp. 13-34 - 13-39. In: Proceedings of the Fifth Federal Interagency Sedimentation Conference. Federal Energy Regulatory Commission, Washington, DC.

Kouwen, N.; Li, R.M.; and Simons, D.B. 1980. A stability criteria for vegetated Waterways. pp. 203-210. In: Proceedings, International Symposium on Urban Storm Runoff. University of Kentucky, Lexington, KY, 28-31 July 1980.

Kropp, A. 1989. Biotechnical stabilization of a debris flow scar. pp. 413-429. In: Proceedings, XX Intl. Erosion Control Association Conference, Vancouver. IECA, Steamboat Springs, CO.

Lagasse, P.F.; Byars, M.S.; Zevenbergen, L.W.; and Clopper, P.D. 1997. Bridge scour and stream stability countermeasures. U.S. Department of Transportation, Federal Highway Administration, Arlington, VA. Report No. FHWA HI-97-030, Hydraulic Engineering Circular 23.

Lutyens, D. 1997. The ECTC's Installation guidelines for rolled erosion-control products. Geotechnical Fabrics Report 15(6):28-32.

Maccaferri, Inc. 2001. Soil Bioengineering and Ecological Systems Techniques. Maccaferri, Inc., Oxford, England.

Maryland. 2000. Maryland's Waterway Construction Guidelines. Maryland Department of the Environment, Water Management Administration, Baltimore, MD.

Maryland Department of the Environment, Water Management Administration [Follweiler, J., ed.]. 2000. Maryland's Waterway Construction Guidelines, Section 3 Channel Stabilization and Rehabilitation Techniques, Baltimore, MD.

Maynord, S.T. 1995. Corps riprap design guidance for channel protection. pp. 41-42. In: C.R. Thorne, S.R. Abt, F.B.J. Barends, S.T. Maynord, and K.W. Pilarczyk (eds.). River, Coastal and Shoreline Protection: Erosion Control Using Riprap and Armourstone. John Wiley and Sons, Ltd., Chichester, UK.

McCoy, S. and Cragburn, B. 2001. Texas makes inroads with highway use of compost. BioCycle 42(2):67-70. February 2001.

McCullah, J.A. IECA Short Course, Bioengineering Techniques for Streambank and Lake Shore Erosion Control.

McCullah, J.A. 1996. Erosion Draw 4.0—Erosion and Sediment Control Manual with Typical Drawing Files for Computer-Aided Drafting, Redding, CA.

McCullah, J.A. 2002. BioDraw 2.0. Salix Applied Earthcare, Redding, CA.

McMullen, J.M. and Burger, M.E. 1999. Final Report, Evaluation of Alternatives to Brushmat Removal Natural Gas Transmission Pipeline No. 63. Terrestrial Environmental Specialists, Inc., Phoenix, AZ.

Mifkovic, C.S. and Petersen, M.S. 1975. Environmental aspects, Sacramento bank protection. American Society of Civil Engineers. Journal of the Hydraulics Division 101(HY5):543-554.

Norman, J.N. 1975. Design of stable channels with flexible linings. U.S. Department of Transportation, Federal Highway Administration, Washington, DC. Hydraulic Engineering Circular 15.

North Carolina Sedimentation Control Commission. 1988. Erosion and Sediment Control Planning and Design Manual. Raleigh, NC.

Oregon Association of Clean Water Agencies, League of Oregon Cities, and the Oregon Water Utilities Council. 2000. Endangered Species Act Assessment Manual. CH2M HILL, Portland, OR.

Oregon Association of Clean Water Agencies. 2002. "Fish Friendly" Erosion Control—An Example Hypothetical Program. CH2M HILL, Portland, OR.

Oregon Department of Environmental Quality. 2005. Erosion and Sediment Control Manual. Prepared by: Geosyntec Consultants, San Diego, CA. http://www.deq.state.or.us/wq/wqpermit/ESCManual/ESCManual.pdf

Oregon Department of Transportation . 1999. Hydraulics Manual Vol. 2—Erosion and Sediment Control. Oregon Department of Transportation, Salem, OR.

Parsons. 1963. Vegetative control of streambank erosion. Federal Interagency Sedimentation Conference, Washington, DC. USDA Miscellaneous Publication 970. pp.130-136.

Peters, S. 2002. Mycorrhiza 101. Reforestation Technologies International, Salinas, CA.

Pezeshki, S.R.; Anderson, P.H.; and Shields, F.D., Jr. 1998. Effects of soil moisture regimes on growth and survival of black willow (*Salix nigra*) posts (cuttings). Wetlands 18(3):460-470.

Polster, D.F. 1998. Introduction to Soil Bioengineering, Participant Manual—Forest Renewal BC, Polster Environmental Services, Duncan, BC.

Presto. 2003a. The Geoweb® Earth Retention System Technical Overview. Presto Products Company, Appleton, WI. GRWERTO-11-Aug-03. www.prestogeo.com

Presto. 2003b. Geoweb® System Earth Retention Construction Package. Presto Products Company, Appleton, WI. GW/RWOOO-18-Dec-03. www.prestogeo.com

R. Alexander Associates, Inc. 2004. Compost Use on State Highway Applications. Composting Council Research and Education Foundation and United States Composting Council (CCREF/USCC), Harrisburg, PA. http://www.epa.gov/epaoswer/non-hw/compost/highway/index.htm

Racin, J.A. and Hoover, T.P. 2001. Gabion mesh corrosion: field study of test panels and full-scale facilities. California Department of Transportation, Division of New Technology and Research, Sacramento, CA. Final Report No. FHWA-CA-TL-99-23.

Reforestation Technologies International. 2003. MycoPak Product Information. TRI-C Enterprises, L.L.C., Chino, CA.

Rexius. (unk.) Erosion Control Manual. Rexius, Eugene, OR.

Risse, M. and Faucette, B. 2001. Compost Utilization for Erosion Control. University of Georgia College of Agriculture and Environmental Sciences, Athens, GA.

Rosgen, D.L. 2000. The Cross-Vane, W-Weir and J-Hook Vane Structures: Their Description, Design, and Application for Stream Stabilization and River Restoration. Wildland Hydrology, Inc., Pagosa Springs, CO.

Schaff, S.D.; Pezeshki, S.R.; and Shields, F.D. 2002. Effects of pre-planting soaking on growth and survival of black willow cuttings. Restoration Ecology 10(2):267-274.

Schiechtl, H.M. 1992. Weiden fur die Praxis [Guidebook for the willows suitable for bioengineering techniques in Middle Europe and the Alps]. Verlag Patzer, Berlin-Hannover.

Schiechtl, H.M. and Stern, R. 1996. Ground Bioengineering Techniques for Slope Protection and Erosion Control. Blackwell Science, Inc., London, England.

Schiechtl, H.M. and Stern, R. 1997. Water Bioengineering Techniques for Watercourse Bank and Shoreline Protection. Blackwell Science, Inc., Oxford, England.

Schiechtl, H.M and Stern, R. 1994. Water Bioengineering Techniques for Riverbank and Shore Stabilization. Blackwell Science, Inc., London, England.

Schiechtl, H.M. and Stern, R. 1994. Water Bioengineering Techniques for Watercourse Bank and Shoreline Protection. Osterreichischer Agrarverlag, Klosterneuburg, Austria.

Schoklitsch, A. [Translated by Samuel Shulits]. 1937. Hydraulic Structures: A Text and Handbook. The American Society of Mechanical Engineers, Brewster, NY.

Schumm, S.A.; Harvey, M.D.; and Watson, C.C.. 1984. Incised Channels. Water Resources Publications, Littleton, CO.

Shields, F.D., Jr. 1991. Woody vegetation and riprap stability along the Sacramento River mile 84.5 to 119. Water Resources Bulletin 27(3):527-536.

Shields, F.D., Jr.; Bowie, A.J.; and Cooper, C.M. 1995. Control of streambank erosion due to bed degradation with vegetation and structure. Water Resources Bulletin 31(3):475-489.

Shields, F.D., Jr.; Brookes, A.; and Haltiner, J. 1999. Geomorphological approaches to incised stream channel restoration in the United States and Europe," Chapter 14. pp. 371-394. In: Darby, S. E. and Simon, A. (eds.). Incised River Channels: Processes, Forms, Engineering and Management. John Wiley and Sons, New York, NY.

Shields, F.D., Jr.; Knight, S.S.; and Cooper, C.M. 2000. Warmwater stream bank protection and fish habitat: a comparative study. Environmental Management 26(3):317-328.

Shields, F.D., Jr.; Smiley, P.C., Jr.; and Cooper, C.M. 2002. Design and management of edge-of-field water control structures for ecological benefits. Journal of Soil and Water Conservation 57(3):151-157.

Sills, G.L. and Fleming, R.L. 1992. Slide stabilization with stone-filled trenches. pp. 1382-1394. In: Proceedings, Specialty Conference on Stability and Performance of Slopes and Embankments-II. ASCE, Berkeley, CA. Geotechnical Special Publication No. 31.

Simon, A. and Collison, A. 2001. Scientific Basis for Streambank Stabilization Using Riparian Vegetation. Proc. 7th Federal Interagency Sedimentation Conference, Reno, NV.

Sloan, R. 2001. Modified brush layers and live pole drains for landslide reclamation. Erosion Control, July/August 2001, pp. 44-47.

Smith, R.R. 2002. Erosion control methods using compost made easy. Soil Erosion & HydroSeeding, Sept/Oct 2003, p.16-20.

Sotir, R.B. and Fischenich, J.C. 2001. Live and inert fascine streambank erosion control. U.S. Army Engineer Research and Development Center, Vicksburg, MS. ERDC TN-EMRRP-SR-31. \\Swag\c\ESCBPM_08.25.03\html\WorksCited\Sotir_RB_2001.pdf

Sotir, R.B. and Nunnally, N.R. 1995. The Use of Riprap in Soil Bioengineering Streambank Protection. Robbin B. Sotir & Associates Inc., Marietta, GA.

Stoffella, P.J.; Li, Y.; Roe, N.E.; Ozores-Hampton, M.P.; and Graetz, D.A. 1996. Utilization of organic waste compost in vegetable crop production systems. In: R.A. Morris (ed.). Managing Soil Fertility for

Intensive Vegetable Production Systems in Asia. Asian Vegetable Research and Development Center, Food and Fertilizer Technology Center, Taipei, Taiwan R.O.C.

Sytle, T.L. and Fishenich, J.C. 2000. Rootwad composites for streambank stabilization and habitat enhancement. U.S. Army Engineer Research and Development Center, Vicksburg, MS. ERDC TN-EMRRP-SR-21.

Taylor, G.H. and Hannan, C. 1999. The Climate of Oregon from Rain Forest to Desert. Oregon State University Press, Corvallis, OR.

Temple, D.M. 1980. Tractive force design of vegetated channels. Transactions of the ASAE 23:884-890.

Texas DOT. (unk.). Special Specification Mulch/Compost Filter Berm for Erosion and Sediment Control. TxDOT, Austin, TX.

Trest, J.W. 1997. Design of structures for the Yazoo Basin Demonstration Erosion Control Project. pp. 1017-1022. In: Wang, S.Y.; E. Langendoen; and F.D. Shields Jr. (eds.). Management of landscapes Disturbed by Channel Incision: Stabilization, Rehabilitation, and Restoration. Center for Computational Hydroscience and Engineering, University of Mississippi, Oxford, MS.

Tyler, R.; Stinson, B.; and King, W. (unk.). Erosion Control and Environmental Uses for Compost. Matrixx Organics Company, Richmond, VA.

U.S. Army Corps of Engineers. 1981. Final Report to Congress, The Streambank Erosion Control Evaluation and Demonstration Act of 1974, Section 32, Public Law 93-251. Main Report. U.S. Army Corps of Engineers, Washington, DC.

U.S. Army Corps of Engineers. 1974. Methodology and effectiveness of drainage systems for airfield pavements. U.S. Army Corps of Engineers, Construction Engr. Research Laboratory (CERL), Urbana, IL. Technical Report C-13.

U.S. Department of Transportation, Federal Highway Administration. 1988. Design of roadside channels with flexible linings. U.S. DOT, Federal Highway Administration, Washington, DC. Hydraulic Engineering Circular No. 15., Publication No. FHWA-IP-87-7.

U.S. Environmental Protection Agency (USEPA). 1999. Storm water technology fact sheet, Turf reinforcement mats. USEPA, Washington, DC. EPA 832-F-99-002.

U.S. Environmental Protection Agency (USEPA). 1997 . Innovative uses of compost: Bioremediation and pollution prevention. USEPA, Washington, DC. EPA530-F-97-042.

USDA. 1954. Handbook of channel design for soil and water conservation. [Prepared by Stillwater Outdoor Hydraulic Lab., Stillwater, OK.] USDA Soil Conservation Service, Washington, DC.

USDA Soil Conservation Service. 1996. Chapter 16: Streambank and Shoreline Protection. Part 650, 210-EFH, Engineering Field Handbook. USDA Soil Conservation Service, Washington, DC.

USDA. 1947 (revised 1954). SCS Handbook of channel design for soil and water conservation. USDA Soil Conservation Service, Washington, DC. SCS TP-61.

USDA. 1972. Minimizing Erosion in Urbanizing Areas. USDA Soil Conservation Service, Madison, WI. [Handbook developed in cooperation with the Wisconsin Assoc. of Soil and Water Conservation Districts].

Virginia Department of Conservation and Recreation. 1992. Virginia Erosion and Sediment Control Handbook, 3rd. edition. Virginia Department of Conservation and Recreation, Division of Soil and Water Conservation, Richmond, VA.

Washington County, Oregon; Clackamas County, Oregon; and City of West Linn, Oregon. 2000. Erosion Prevention and Sediment Control Planning and Design Manual. Washington County, Oregon; Clackamas County, Oregon; and City of West Linn, Oregon.

Washington Department of Ecology. 2001. Stormwater management manual for Western Washington. Volume II—Construction stormwater pollution prevention. Washington Department of Ecology, Olympia, WA. Publication Number 99-12.

Washington Department of Fish and Wildlife. 2002. Integrated Streambank Protection Guidelines. Washington Department of Fish and Wildlife, Olympia, WA. [Published in cooperation with Washington Department of Transportation and Washington Department of Ecology]. June 2002.

Washington State. 2003. Integrated Streambank Protection Guidelines. Chapter 6—BankProtection Techniques. Washington DOT and Washington Dept. of Fish and Wildlife, Olympia, WA. [available in PDF format from Washington Dept. of Fish and Wildlife—Habitat Technical Assistance http://www.wa.gov/wdfw/hab/ahg/ispgdoc.htm].

Water and Engineering Technology, Inc. 1989. Geomorphic analysis and bank protection alternatives report for Sacramento River (RM 178-178) and Feather River (RM 0-28). [Prepared for the U.S. Army Corps of Engineers Sacramento District, Sacramento, CA]. Water and Engineering Technology, Inc., Fort Collins, CO.

Wetland Research Program. 1998. Shoreline and channel erosion protection: Overview of alternatives. U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. WRP Technical Note HS-RS-4.1.